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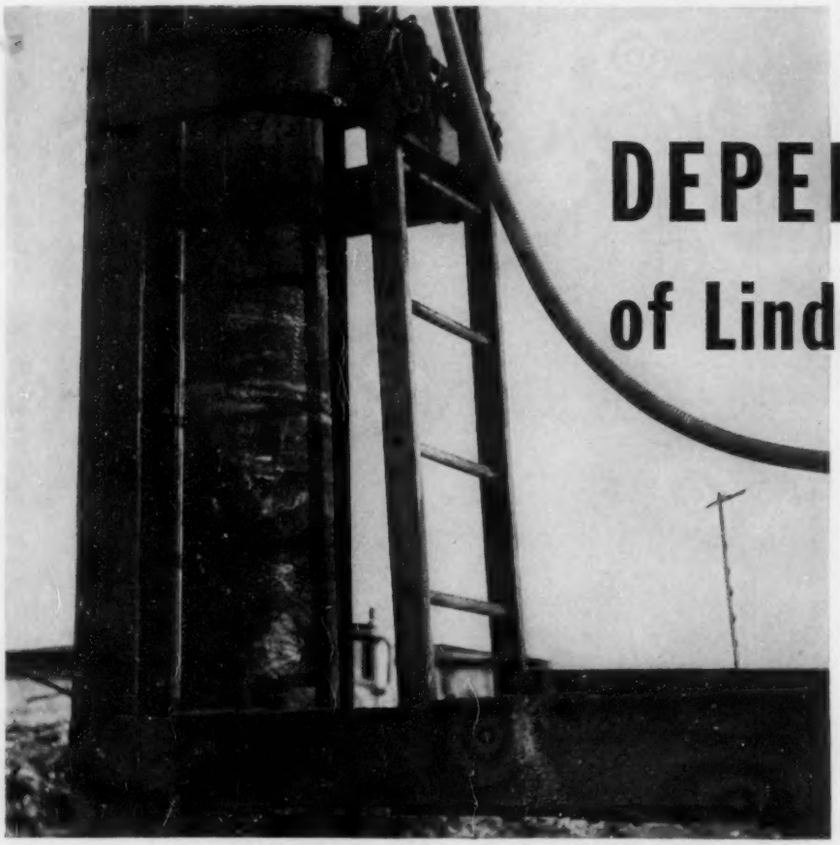
Linde Process Service

proves the DEPENDABILITY of Lindewelded Pipe for FIRM Foundations



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THE AMERICAN WELDING SOCIETY JOURNAL

WM. SPRARAGEN, Editor | VOL. 14 | NO. 2

FEBRUARY

Contents

Technical Papers, Items and Reports

Page

Gas Cutting (*Courtesy Air Reduction Company*) ..... Frontispiece
Welding Effects Economies in Maintenance of Hotel Power and Restaurant Equipment, by *W. D. Wilkinson, Jr* 2
Welded Pipe Lines, by *H. C. Price* 4
Discussion: Alternating-Current Arc-Welding Papers, by *K. L. Hansen* 5
Alternating-Current Arc-Welding Transformer and Circuit Characteristics, by *A. M. Candy* 7
Steel Frame House Built by Arc Welding, by *A. F. Davis* 8
Arc Welding Used in Nine-Story Addition to Department Store Building, by *W. T. Cook* 10
A. W. S. Tentative Recommendations Describing Procedure to Be Followed in Preparing for Welding or Cutting Certain Types of Containers Which Have Held Combustibles 11
A. W. S. Bulletin on Symbols 15
A. W. S. Marine Code for Welding and Gas Cutting—Part D, Rules for the Fusion Welding of Hulls and Hull Parts 16
Spot Welding Combinations of Metals 18
Qualifying Welding Operators for Structural Work, by *Gilbert D. Fish* 19
Use of Polarized Light as Applied to Welding Products, by *E. W. P. Smith* 21
Discussion, by *T. H. Evans* 24
Discussion on "Investigation of Welded Seat Angle Connections," by Inge Lyse and Norman G. Schreiner, by *Cyril D. Jensen* 24
Current Welding Literature 26

Supplement

An Investigation of Welded Seat Angle Connections, by *Inge Lyse* and *Norman G. Schreiner* 1
A Photoelastic Study of Bending in Welded Seat Angle Connections, by *Inge Lyse* and *Douglas M. Stewart* 16

Society and Related Activities

Corrosion Resisting Steels 27
Amendments and Addition to By-Laws Adopted November 5, 1934 27
Committees Scheduled to Meet during 1935 A. S. T. M. Committee Week 27
Fourth Annual Welding Conference 27
Lafayette Engineering Conference 27
William Zorn 28
Specification Documents for Building Materials and Construction 28
Employment Service Bulletin 28
Section Activities 28

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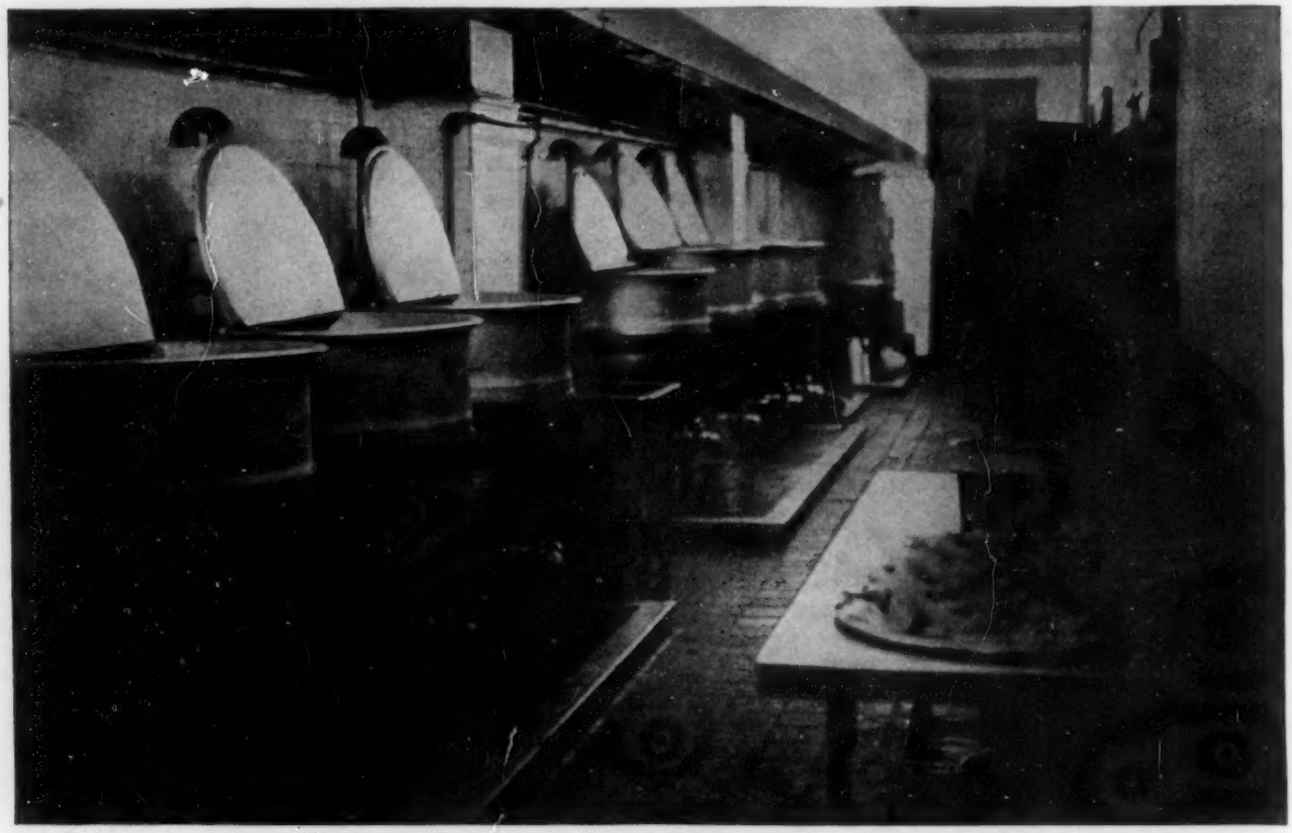

Fig. 1—Cleaning Agents and Food Acids Cannot Corrode the Welded Sheets of Monel Metal under the Soup Kettles

Welding Effects Economies in Maintenance of Hotel Power and Restaurant Equipment

By W. D. WILKINSON, JR.†

AS SOON as hotel managers have studied the many advantages of the oxyacetylene process and have learned how by means of the blowpipe the cost of maintenance and replacement in hotels can be reduced, they will become enthusiastic about this money-saving process. Indeed, the use of the oxyacetylene welding process has already been a routine maintenance practice in many hotels for years. In one middle western hotel the first work done by means of the blowpipe was on a special pipe known as a "water back." This pipe runs into the furnaces and carries water into the rear end of the stokers so that they are protected from the heat of the flames. In passing from the front wall of the furnace through the fire chamber to the rear end, the pipe is exposed for several feet to the hottest part of the fire.

At first the engineer was not permitted to use a welded joint of any kind on the parts of the unit that were exposed to the fire. He was ordered to put in a single length of pipe extending the full distance. Inasmuch as the best pipe available at that time was made with a longitudinal seam, a great deal of difficulty was encountered because the seam would open up. Finally the engineer, who realized the oxyacetylene welding was the logical answer, induced the officials to allow a pipe with welded joints to be set up in the fire chamber. This was 9-gage boiler tubing and it had two welded joints exposed to the hottest part of the fire. The engineer was rewarded by finding that this particular section lasted for four years, much longer than the pipe originally installed. The tubing used at present has been in the furnace for several years and it has several oxyacetylene welded joints exposed directly to the flame. Even now regular inspection finds it in good condition.

† Technical Publicity Department, The Linde Air Products Company.

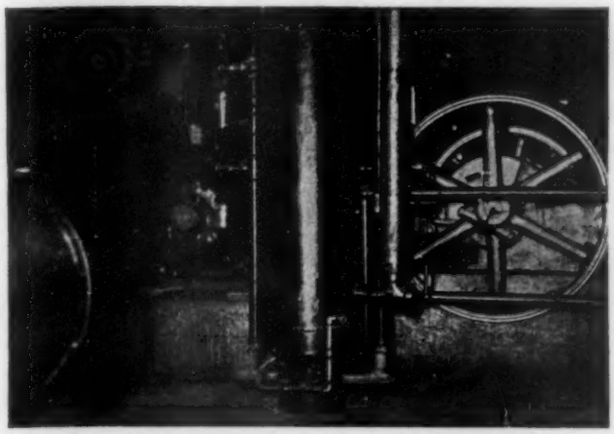

Fig. 2—18 In. Diameter Scrap Pipe Was Used in the Fabrication of This Heat Interchanger in a Hotel Power Plant

Another use for the oxyacetylene process in the maintenance of power equipment in the hotel is the rebuilding of worn surfaces with hard-facing material. Ordinary chain grate stoker sprockets, being made of cast iron, undergo considerable wear. It was formerly a considerable job to remove worn sprockets and replace them with new ones, for it was necessary to rip out the entire stoker. Now, by hard-facing the worn surfaces with Haynes Stellite, these stoker sprockets give several times the service they otherwise would.

Stoker dogs, the ratchets that motivate the stoker gears, are also hard-faced. In order to facilitate this hard-facing operation, which more than triples the useful life of the stoker dogs, the engineer had fabricated a little grinding jig that aids the correct grinding of these dogs after they have been rebuilt.

Many other tools and articles of equipment for the boiler room are fabricated by means of the blowpipe: furnace hoes, rakes, clinker hooks, with both single and double pronged points, and other necessary stoking and fire-maintaining equipment. Both bronze-welding and steel-welding are used in the various fabrication operations. Hoe lips and other wearing surfaces are rebuilt with wear-resisting material, thus increasing their useful life at least two years. Some of the hoes have been in use for three years and are still in splendid condition. The portable carbon dioxide recorder has been mounted on an all-welded frame of angle iron so that it can be shifted from one boiler to another. This, too, is still in service after years of use.

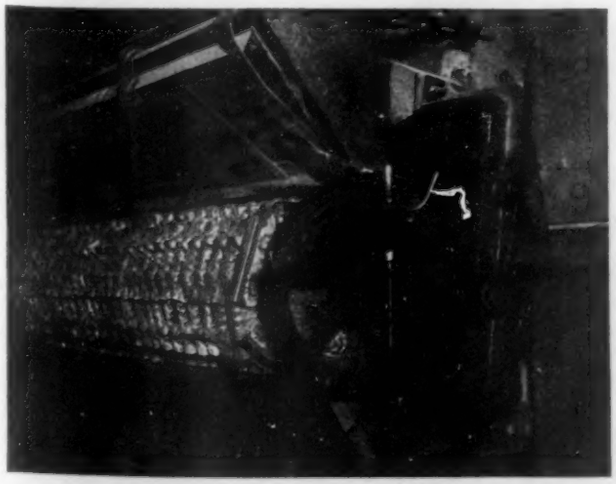

Fig. 3—The Sprockets and Ratchets of This Chain Grate Stoker Are Hard-Faced for Triple Service

Having some 18 in. diameter pipe on hand, the engineer used this pipe in the fabrication of a heat interchanger, which he installed in the line to increase the efficiency of the power plant. It was necessary to purchase only some 18 in. flanged and dished heads. The centers of these heads were cut out in order to insert and weld into place 12-in. pipe which goes about 30 ft. up through the center of the interchanger. The expenditure of the small amount of money and the few days necessary for making this equipment were amply repaid by the increased efficiency of the power plant.

The oxyacetylene process enabled another problem in efficiency to be solved. The house pumps for the domestic water supply could raise the water to the top of the hotel only at a pressure that was insufficient. Accordingly some air pressure cylinders about 12 ft. high were made of 18-in. pipe with flanged and dished heads. These allowed the pumps to operate at a much higher efficiency. A 14 in. diameter compressor piston which had become badly worn was rebuilt by bronze-welding. The job was so successful that this type of work is now part of the standard reclamation practice, and the purchase of new pistons is eliminated.

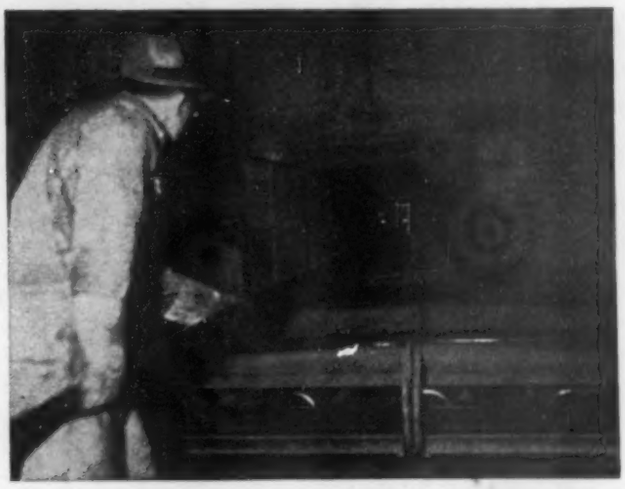

Fig. 4—The Ordinary Ash Hoe Will Last but Six Months While a Bronze-Welded Ash Hoe with a Hard-Faced Lip Is Good after Two or Three Years

Many small jobs connected with the power plant were successfully accomplished through the use of the blowpipe and many annoyances and mishaps that otherwise might be classified as emergencies were corrected. For instance the smoke elimination jets for the furnaces were extremely noisy. This was corrected by the use of mufflers fabricated from scrap steel pipe by bronze-welding. Another time a carbon dioxide compressor valve cap made of 1-in. cast iron had been broken by the pressure of nuts drawn excessively tight. This casting was easily bronze-welded so that it withstands a pressure of 1,000 lb. per sq. in., and it has now been in operation for a long time.

Whenever old carbon dioxide condenser coils or any kind of piping is in need of repair, the old piping is cut out and new piping is inserted and welded into place. All the hard labor of threading and screwing piping is eliminated.

As mechanical joints in steel piping, whether screw or flange, develop leaks, they are replaced with welded joints. Old flanges are cut out and a short length of pipe is substituted. So many of these short lengths have been inserted and welded into place that eventually the complete system will be entirely welded. The engineering crew goes through the entire piping system,

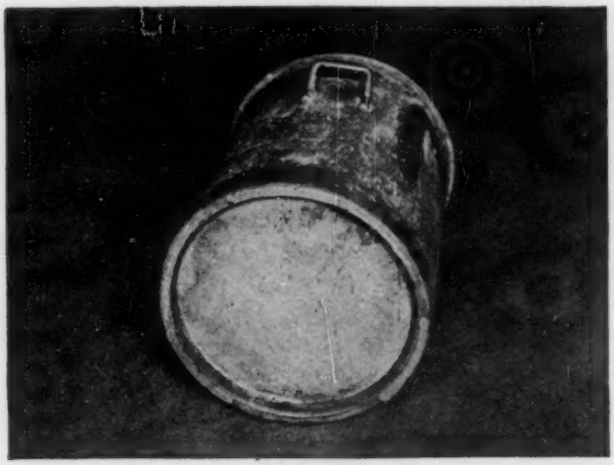

Fig. 5—Garbage Cans and Ash Cans Strengthened by Bronze-Welding and Hard-Faced on the Bottom Rim Resist the Abrasion of Concrete Floors

ripping out all flanges that are in hidden spots. The welded joints which replace them may be completely forgotten.

Steam lines and screw couplings in a hotel bakery are a poor combination. Once in a bakery, when a faulty length of pipe sprang a leak, the engineering crew was able to remove this length and quickly weld into place a new piece. In this case speed was important because the bakery must have steam as early as 3:00 A.M.

Welding is utilized in so many ways in the hotel bakery and restaurants that every application cannot be enumerated. Ash cans and garbage cans, for instance, were formerly pushed around so much on cement floors that the cans would wear out in six months. When, however, they were rebuilt and hard-surfaced they lasted for seven years, and they were much easier to push around because the friction was less. Sometimes the cans were hard-faced in only three spots on the outside bottom and at other times a small rim of wear-resisting alloy was built up completely around the edge.

All kinds of kitchen ware, iron, copper and aluminum, are mended and made usable by welding. Pots and pressure cookers all can be repaired and are repaired in many hotels. The tile floor around the soup kettles is eaten away in many spots by the dripping and splashing of cleaning materials used in the kettles and by the acids of certain foods, and becomes corroded again as replaced. The chief engineer therefore covered the floor with Monel metal sheets, and had all the seams oxyacetylene welded. The floor has long been in use but shows no signs of deterioration.

Ice and scrap bins, brass hinges on refrigerators, lunch counter chairs and even brass cuspidors are all repaired by bronze-welding. There is seemingly no limit to the number of applications in hotels that are found for the oxyacetylene blowpipe.

It is now evident that the oxyacetylene process should not be used simply as a last resort when other methods fail, but it should be a regular routine means of maintenance. It should not be limited to the great hotels with large armies of maintenance engineers; but the smaller organizations, if they will only get in touch with a local welding shop, can also obtain the advantages of oxyacetylene welding and cutting. The counsel of an experienced welder can be used profitably in making a systematic study and inventory of all broken or worn metal parts that can be welded economically. The managers of smaller hotels will find it exceedingly profitable to contract with a welding shop on an annual basis for all their repair and maintenance work.

Welded Pipe Lines

By H. C. PRICE*

THE photographs illustrate the electric welding of the Sunset Reservoir Supply Project in the City of San Francisco. The joints were of the bell and spigot type, and were welded both inside and out, as shown by the pictures. The line was 8900 ft. in length, and the pipe was 54 in. in diameter, and $^{5}/_{16}$ in. and $^{3}/_{8}$ in. in thickness. Electric welding was done by our Company. The general contractors were Barrett & Hilp of San Francisco.

Pictures are also shown of the recently completed Estero Bay Line laid by the Standard Oil Company of California. This was a 12-in. oil line and was laid over the Coast Range; the entire line was electric

* President, H. C. Price, Inc.

Arc Welded Estero Bay 12-in. Oil Line for the Standard Oil Company of California, Showing Line Being Laid over the Coast Range

Arc Welded 54-in. Sunset Reservoir Supply Water Line in San Francisco

welded. In many places the country was so rough and inaccessible that welding cables of from 1500 ft. to 2000 ft. in length had to be used from the welding machines to the pipe line. This line was laid with a butt joint without a backing-up ring. Lindgren & Swinerton Inc., of San Francisco was the general contractor; our Company was the electric welding contractor.

Discussion: Alternating-Current Arc-Welding Papers*

By K. L. HANSEN†

MR. CANDY emphasizes that a high open-circuit voltage is essential to enable the operator to readily strike and maintain the arc. He also points out the rather obvious relation that with a higher open-circuit voltage the variation in arc current is less for a given variation in arc length or arc voltage than when a lower open-circuit voltage is employed. In other words, the volt-ampere characteristic is steeper over the welding range. That makes for better welding, but reduces the power factor because the kva. input is higher for the same kw. output of the arc. So the objection to the A.C. arc-welding transformer, that it constitutes a single phase load at low power factor, has not been eliminated to any extent in the later types of equipment.

In the paper, the power factor at 110 volts open circuit is stated to be 40% at full load and 40 volts across the arc. That apparently does not take in the impedance drop in the welding leads which, it is pointed out in the paper, may be very considerable under certain conditions. Furthermore, a great deal of welding, even with a coated rod, is done at less than 40 volts across the arc, which reduces the power factor still more. It is probable, therefore, that under actual operating conditions the power factor will at times be considerably less than 40%.

It is suggested in the paper that the power factor may be improved by the use of a static condenser. However, the use of a synchronous condenser, also proposed in the paper, is more effective in so far as it tends to restore balance to the system in addition to correcting the power factor. When the voltages on a three-phase line become unbalanced, rotating apparatus such as induction motors connected to the line will tend to restore the balance, but they do so by means of parasitic currents circulating in the stator and rotor windings. These parasitic currents do no useful work, in fact they produce a drag on the rotating element of the motor and increase the losses and heating. In discussing the efficiency of a welding transformer, these losses in neighboring apparatus, resulting from the unbalance of the system, should be taken into account, but are ordinarily neglected.

To be effective, a synchronous condenser should have sufficient capacity to take care of both the low power factor and the unbalancing, and, in most cases, the kva.

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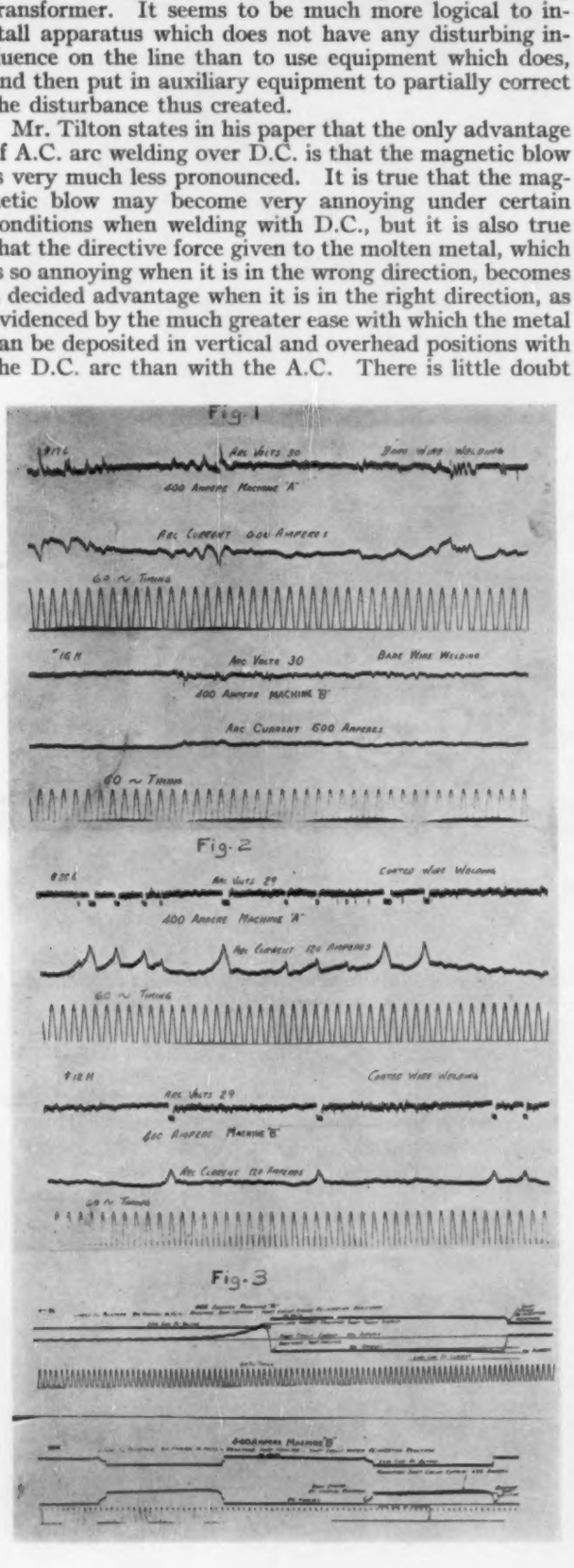
* Papers presented at the 14th Fall Meeting of the AMERICAN WELDING SOCIETY, October 4, 1934.
"Alternating Current Arc-Welding Transformer and Circuit Characteristics," by A. M. Candy.
"Automatic A.C. Arc Welding Class 1 Pressure Vessels," by O. A. Tilton.

† Consulting Engineer, Harnischfeger Corp.

rating is apt to be as high or higher than that of the transformer itself. Mr. Tilton is, therefore, entirely correct when he states that the first cost of an A.C. installation will be as high, or probably higher, than the first cost of a D.C. installation if corrective apparatus of sufficient capacity is to be installed along with the welding transformer. It seems to be much more logical to install apparatus which does not have any disturbing influence on the line than to use equipment which does, and then put in auxiliary equipment to partially correct the disturbance thus created.

Mr. Tilton states in his paper that the only advantage of A.C. arc welding over D.C. is that the magnetic blow is very much less pronounced. It is true that the magnetic blow may become very annoying under certain conditions when welding with D.C., but it is also true that the directive force given to the molten metal, which is so annoying when it is in the wrong direction, becomes a decided advantage when it is in the right direction, as evidenced by the much greater ease with which the metal can be deposited in vertical and overhead positions with the D.C. arc than with the A.C. There is little doubt



that when all of the phenomena become more fully understood, the directive force given to the molten metal in D.C. welding, which is designated magnetic blow, will be so controlled as to become an advantage under all conditions.

Mr. Candy cautiously, and perhaps wisely, refrains from making any comparisons in the quality of weld metal deposited with A.C. and D.C. arcs. Others are not so prudent. Some extravagant claims are being made these days for A.C. welding in heavy plates over D.C. from the standpoint of soundness of weld metal.

Mr. Tilton in his paper describes an installation using A.C. current in connection with automatic arc welding. If I observed his chart on the lantern slide correctly, he showed that 16 passes were used in welding $1^1/_2$-in. plate, using $^1/_4$-in. rod, the current at no time exceeding 400 amp. Some years ago I saw a gasoline cracking still in the process of being welded, where a D.C. current of 900 to 1000 amp. was used with a $^7/_{16}$-in. rod. Twelve to thirteen passes were sufficient to make a weld in a $2^1/_2$-in. plate. The installation cited by Mr. Tilton is hardly an illustration of his statement that higher welding currents can be used with A.C. than with D.C. Only a few days ago I had occasion to discuss the condition of some of these welded stills, after they have been in service a number of years, with an engineer whose job at one time was to inspect vessels of this kind. He informed me that an ideal time to inspect the welds, as well as the parent metal, is after several years of operation when corrosion has had a chance to do its work. He stated that the excellent condition of the welds was eloquent testimony to their soundness.

Within the last year or two the question of qualifying operators for particular work has become one of paramount importance. We, therefore, became very much interested in finding out just what the characteristics of a welding generator should be in order that an average operator can readily meet exacting qualification tests. Figure 1 shows oscillograms of the welding currents and welding voltages of two machines, one designated as machine "*A*" and the other as machine "*B*." These tests were made under exactly the same conditions, using the same instruments, and it will be observed that machine *B* has a very much more uniform arc current than machine *A*. The same is true of Fig. 2, in which the welding current was reduced on both machines to 120 amp. A number of similar comparative tests made under varying conditions showed the same general trend of a smoother welding current with machine *B* than with machine *A*.

Test specimens were then made in $1^1/_4$-in. plates, joints being of the double-U type. As nearly as possible, conditions were maintained exactly the same. The same operator made the samples, using the same size and make of weld rod, same current, same number of beads and same technique. Test specimens made with machine *B* showed on the average 20% better results as regards yield point and ultimate tensile strength, and 30% better elongation on the free-bend test. These tests are borne out in actual practice by the greater ease with which an operator can meet his qualification tests on a machine with characteristics similar to *B* than he can on a machine with characteristics similar to *A*.

As it is the more uniform welding current which gives machine *B* the superior welding characteristics over machine *A*, it obviously becomes desirable to have a more definite measure of current uniformity than any that so far have been proposed. Tests made as shown in Figs. 1 and 2 do not have much meaning except as comparative tests when made under identical conditions. A test for uniformity should be such that it can readily

be duplicated under controlled conditions, and must be independent of the personal element and also the factors introduced by the qualities of the welding electrodes, which, although important, are really extraneous elements in testing arc-welding generators.

The United States Navy specifications call for a test of current recovery which I feel can be made an excellent test for current uniformity by giving it a different interpretation from the one at present ascribed to it by the Navy specifications. The test I have in mind specifies the machine to be loaded on the resistance at normal load, 40 volts across the arc. The resistance is then short-circuited by means of a switch closing a circuit shunted around the resistance. After conditions have become stable, the short circuit is opened, reinserting the resistance in the circuit. By means of an oscillograph a record is made of the current fluctuations resulting from this resistance variation.

Figure 3 shows oscillograms of currents and voltages made according to this test on machines *A* and *B*. The Navy specification states that upon reinsertion of the resistance in the circuit the momentary drop of current should not be below 70% of normal, and the current should be back to within 5% of normal in not more than 0.3 sec. It says nothing about the current peak when the resistance is short-circuited. But it follows that if uniformity of current is what we are after, the extent to which the current rises above normal when the resistance is shorted is just as important as the extent to which the current drops below normal when the resistance is reinserted. I therefore propose the following as a definition of "Current uniformity coefficient."

$$\frac{\text{Normal current}}{\text{Normal current} + \text{fluctuation of current min. to max.}}$$

It will be observed that if the current fluctuation is zero, this ratio is unity, or 100%. This definition of current uniformity coefficient is similar to the definition of efficiency as the ratio $\frac{\text{output}}{\text{output} + \text{losses}}$. Comparing the two machines according to that definition, we find on machine *A* that the peak current upon shorting the resistance was 1490 amp., and the dip upon reinserting the resistance was down to 240 amp., or a total fluctuation of 1490 − 240 = 1250 amp., and the current uniformity coefficient $\frac{400}{400 + 1250} = 0.242$, or 24.2%

The same test on machine *B* showed a peak current of 688 amp. and no dip, the current returning to 400 amp. immediately upon reinserting the resistance. The total current variation is then 688 − 400 = 288 amp., and the current uniformity coefficient $\frac{400}{400 + 288} = 0.582$, or 58.2%.

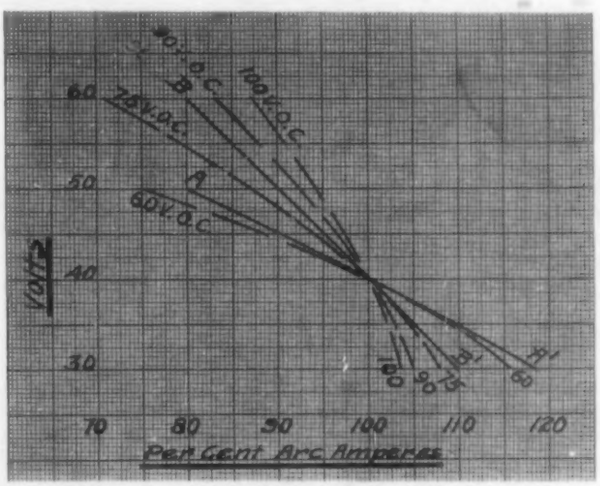
The same definition of uniformity coefficient may be applied to an A.C. circuit. Let us assume for a moment that the welding current of the transformer is a pure sine wave. Its maximum value is therefore 41% higher than the effective value, so that the current fluctuation by virtue of its being an alternating current, is from zero to 1.41 × the effective current. The uniformity coefficient is then $\frac{\text{Effective}}{\text{Effec.} + 1.41 \times \text{Effec.}} = 0.413$, or 41.3%, which compares very favorably with machine *A*, but is not nearly so good as machine *B*. However, there are transients in the secondary current of the welding transformer which tend to lower this uniformity coefficient. On the other hand, if the wave can be made more of a flat-topped wave so that the maximum, or peak value, is closer to the effective value, this coefficient may be higher.

Alternating-Current Arc-Welding Transformer and Circuit Characteristics*

By A. M. CANDY†

IN REPLY to Mr. H. A. Winne's discussion (appearing in the October 1934 JOURNAL) of the above paper the author would like to point out a few conditions which should be considered in designing welding equipment. In the first place it is generally recognized that the alternating-current arc is more difficult to use for welding than the direct current arc unless some special features are designed and supplied in the equipment supplying power. For example very satisfactory welding can be done using bare electrodes with power taken through a resistance from a 60-volt D.C. line. Now, if everything is left the same but instead of 60 volts D.C. we substitute 60 volts A.C. 60 cycles, it is almost impossible to do welding. To say the least, it is not commercially satisfactory. In other words when alternating current at 60 cycles is to be used the apparatus must in a sense be superior to direct-current apparatus to produce equally satisfactory results.

Now the shape of the volt-ampere curve and the open-circuit voltage, together with other characteristics, determine how satisfactory the apparatus will be.



The attached curve shows sections of volt-ampere curves through the operating range required for covered electrodes. Curve *A* is for a typical D.C. arc-welding generator of a certain rating and curve *B* is for an entirely different rating and manufacturer. The performance of the machine *B* is very good but in the author's opinion an A.C. transformer should have *a steeper performance curve*. For this reason we believe that the ultimate preference will be in favor of 90 to 100 volts open circuit as indicated by the curves so labeled rather than even 75 volts.

It is understood, of course, that the above discussion does not apply to transformers provided with special arc stabilizers such as high frequency oscillators.

* Presented at Fall Meeting, A. W. S., New York, Oct. 1934.
† Welding Engineer, Westinghouse Electric & Mfg. Company.

Steel Frame House Built by Arc Welding

By A. F. DAVIS†

THE largest single steel frame house thus far built, and one of the first of its type in which arc-welded construction has been used throughout, is being erected in the exclusive Ottawa Hills residential section of Toledo, Ohio, for O. C. Rohde from designs prepared by Myron T. Hill, Toledo architect. Fireproof construction, greater stiffness and rigidity, as well as higher speed of assembly, are all provided for by the design of the arc-welded steel frame.

This 12-room residence has a total cubic content of 53,450 cu. ft. The spread of the house with connecting garage is about 83 ft., depth 35 ft. (see Fig. 1).

The front door leads into a flagstone-paved vestibule, and up two steps into the main hall from which the living room, 15 ft. wide by 24 ft. long, is reached through an arched opening. The dining room and study are also reached from the stair hall. A completely screened, flagstone-paved porch opens from the study. Between dining room and kitchen is a servery with sink and cupboards.

Four bedrooms and two bathrooms comprise the second floor of the house. The master bedroom, over the living room, is supplemented by a dressing alcove. Adjacent to the master bedroom and over the study is a guest bedroom, both rooms connected with the same bathroom. A similar arrangement is used with the daughter's room over the dining room and her guest bedroom over the kitchen. A sewing room located over the motor driveway acts as a connecting passage from the rear stair hall to the two-room servants' quarters over the three-car garage.

The basement of the house contains a recreation room and a completely equipped owner's workshop. The boiler room, containing the heating and air conditioning equipment, is only 10 ft. by 11 ft. An outside stairway provides easy access to the laundry.

The walls of the house are composed of large panels one story in height assembled by shop welding. These panels were fabricated from standard 3 in. 4.1 lb. channels as studs and angles, plates, etc., as necessary. A total of 45 panels was used in construction, the largest being 10 ft. by 20 ft. The first floor panels have a continuous 3-in. channel sill as base and a continuous girt angle at the top to receive the second floor channels. The second floor panels have a girt angle base which rests on top of the second floor channels. Top girt angles are $2^1/_2 \times 2 \times {}^1/_4$ in. while bottom girt angles are $3 \times 2^1/_2 \times {}^1/_4$ in. The channel studs of both panels overlap so that a field weld could be made to the opposite girt angle, giving a continuity of wall construction.

In erection of the house the first step was accurate placing of bearing plates and anchor bolts. All plates were brought into alignment and grouted solidly in place on the 12-in. load-bearing tile basement wall. A

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Fig. 1—Largest Single Steel Frame House Ever Built—Certain Forerunner of the Home of the Future—Erected Entirely by the Shielded-Arc Process of Welding (Top)

Fig. 2—Placing a Welded Panel Which Was Delivered Fully Fabricated Beforehand by Arc Welding and Ready for Welding in Position (Center)

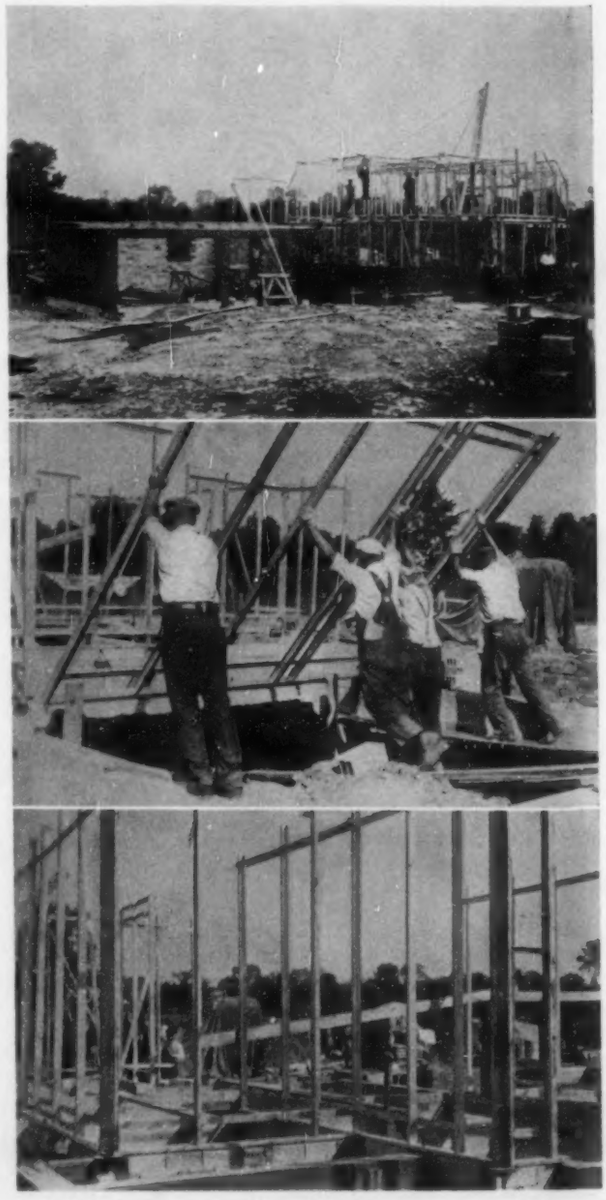
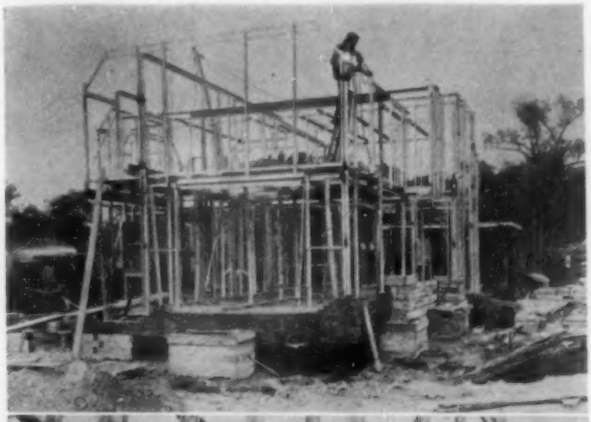


Fig. 3—Whole Sections Replace Pieces in Modern Arc-Welded House Frame Construction. Only 45 Panels Were Required in the Entire Wall Frame of the House

Fig. 4—No Noise of Hammers Attends Construction of This Modern Residence. With a Steady Hissing, the Electric Arc Welds the Framework into One Single Piece



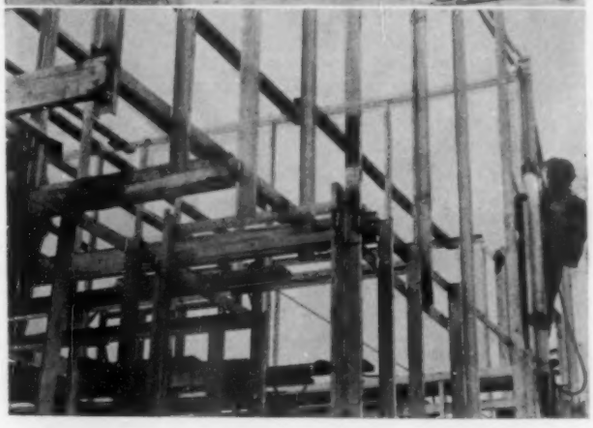


Fig. 5—The Steel Carpenter Uses Only One Tool—the Electric Arc—in Erecting the Entire Steel Framework of Today's Fireproof Home

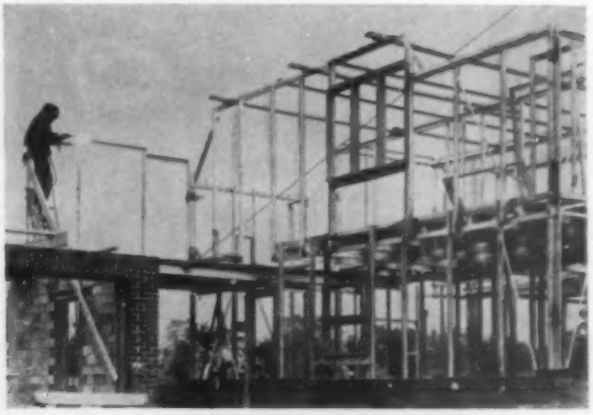


Fig. 6—The Steel Carpenter, Appearing at Some Grotesque Being, Joins Steel to Steel with a Flash and a Sizzling Hiss

minimum of two bearing plates was placed under each panel. Wall panels were subsequently welded to all bearing plates.

The next step was to set the first-story wall panels in place and bolt them together at the panel intersections with $^1/_2$-in. bolts which were used only for assembly. (See Figs. 2 and 3 for erection of first-floor framework.) The first-floor channels were next set in place, bearing directly on the 3-in. channels which acted as sills. Floor channels and wall panels were then aligned, plumbed and welded. After the wall panels had been welded to the bearing plates, continuous grouting was placed under the channel sills to secure continuous bearing.

The next step of erection was to place the second floor channels. The second floor wall panels were then bolted together at the panel intersections. The floor channels were welded to both first- and second-story girt angles. Extended studs of the first story were welded to the second-story girt angles and the second-floor studs were welded to the first-story angles. The second-story wall panels were then welded together and the third-

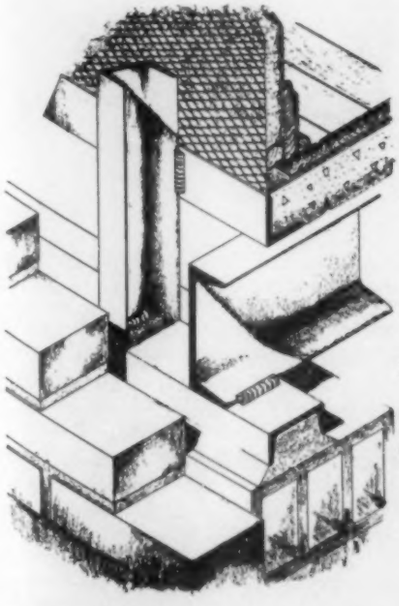


Fig. 7—Section through Wall at First Floor Level, Showing Floor Construction, Welding and Sill Detail

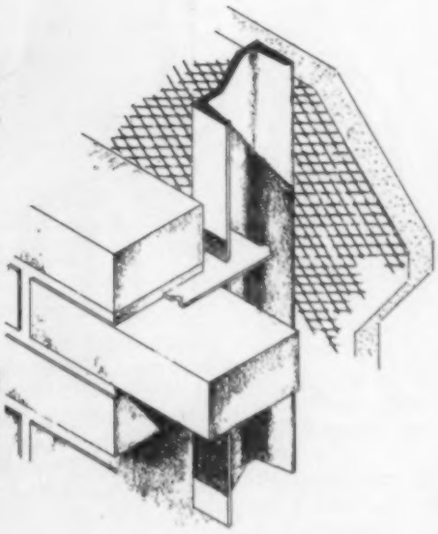


Fig. 8—Typical Wall Section Showing Metal Clip Fastening Brick Veneer to Frame

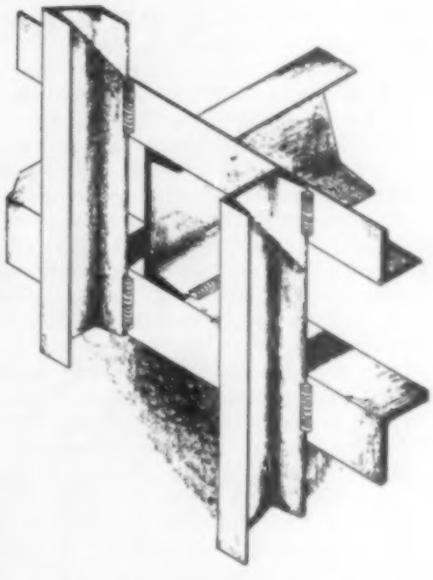


Fig. 9—Detail of Steel Framing at Second Floor Level Showing Welding

floor beams set, brought into alignment and welded. (See Figs. 4, 5 and 6 for views of second-story framework erection. Figure 6 shows the welding of the 44th panel, the next to the last to be erected.)

A clear, unobstructed passage in the wall for all ducts, pipes, conduits, etc., was provided by placing all girt angles on the interior of the frame, except at the eave.

All welding, both in the shop and field, was done with the shielded-arc process with equipment made by our Company. Quarter-inch fillet welds were used almost entirely. After welding, all welds, as well as the steel, were covered with aluminum paint.

Standard 6-in. 8.2-lb. channels spaced 3 ft. to 3 ft. 6 in. on centers carry the floor construction. A $^3/_4$-in. rib lath, which acts as a form for concrete and also as reinforcement, in the concrete floor slab, was secured to the top of the channels. Ceilings are metal lath and plaster, suspended immediately below the floor channels. The total depth of floor from ceiling to finished floor is eleven inches.

The wall is faced with a 4-in. brick veneer. A one-in. air space separates brick and steel. Three-inch channels, finished on the interior with metal lath and plaster, comprise the frame, giving a wall thickness of 9 in. The space between the brick veneer and the metal lath is filled with rock wool insulation.

Hard-burned common brick will be used to face the house. The front entrance is flanked either side by sandstone, which is also to be used in the chimney.

Loose angle lintels carry the brick veneer over all openings. Beams 8 in. and 10 in. in depth were used over the garage openings. Floor construction over the garage is carried on 8 in. 11.5 lb. channels. Brick veneering is fastened rigidly to each stud every seventh course of brick, providing mutual stiffening and lowering the stress on the channel studs to a unit stress of 12,800 lb. per sq. in.

A total of 15 tons of steel was used in construction of this residence. It was divided as follows: 46% for the wall panels, 45.7% for floors and 8.3% for lintels, brick fasteners, etc.

Whereas former jobs of steel construction have figured as 8 to 10% more than with wood, in this job the cost of steel construction is approximately the same as that of wood.

C. Merrill Barber, Cleveland, was the structural engineer. The house was erected by George Lathrop and Son, Toledo, Ohio, and all welding, both shop and field, was done by the Art Iron and Wire Works of Toledo. The steel was furnished by the Carnegie Steel Company.

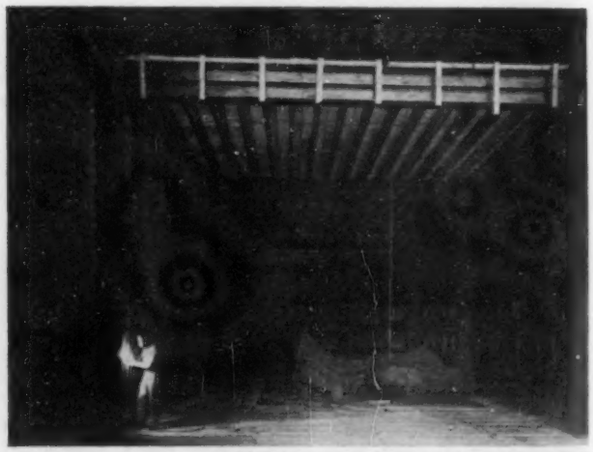
In regard to the simplicity of erecting the framework of this house, Walter Lathrop, speaking for the contractors, stated that the only equipment used was an A-frame and a welding machine.

Arc Welding Used in Nine-Story Addition to Department Store Building

By W. T. COOK*

DURING the recent erection of a nine-story addition to the building of the Block Department Store in Indianapolis, one of the largest stores of its kind in the State of Indiana, electric arc welding found two interesting structural applications. In one of these applications, the exterior wall columns of the existing building were strengthened to bear the additional floor loading of the adjacent bays of the addition, and in the second, galvanized, corrugated sheet-iron was laid to form a support for the concrete floors during pouring.

In strengthening the existing exterior wall columns, steel plates were arc welded across the flanges of the H-columns, extending from the basement to the top floor, inclusive. At the basement level, these plates were 14 in. wide and $2^1/_8$ in. thick, the sizes being graduated on the way up until, at the top floor, the plates were 10 in. wide and $1^1/_4$ in. thick. Fillet welds were used, each fillet being 3 in. long and spaced 6 in. from adjacent welds. As the fillets had to be $^1/_2$ in. thick, a number of layers (passes) were applied in building up each weld. A total of 5000 of these welds was used, the work requiring 1200 lb. of $^3/_{16}$-in. welding electrode.



Welding Operator Making Weld between Wall Column and Strengthening Plate. Corrugated Sheet Flooring in Foreground

In laying the corrugated sheets for the concrete flooring, 400 lb. of $^1/_4$-in. electrode were used in making approximately 20,000 tack welds through from two to four thicknesses of the metal.

The welding work was done by the Sutton-Garten Company of Indianapolis, using two arc-welding sets and approximately 900 ft. of welding cable between the welding sets and the operators.

* News Bureau, General Electric Company.

American Welding Society Tentative Recommendations Describing Procedure to Be Followed in Preparing for Welding or Cutting Certain Types of Containers Which Have Held Combustibles

January 15th, 1935

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Recommendations for Proper Procedure in Preparing for Welding or Cutting Certain Types of Containers Which Have Held Combustibles

Scope.—These recommendations are intended to apply to the preparation for welding and/or cutting of metal containers which have held flammable solids, liquids or gases. These practices are equally desirable where any such container is to be subjected to any type of hot work or any operation that might create a spark or flame.

[NOTE: See Regulations governing Marine Fire Hazards (1930), Appendix C, for partial list of combustibles.]

These recommendations do not assume jurisdiction over the following classes of containers.

1. Containers when entered by workmen for cleansing from inside.

2. Tanks, bunkers or compartments on board ship.

[NOTE: Covered by Appendix A of the Regulations governing Marine Fire Hazards, published by the National Fire Protection Assn., 60 Batterymarch St., Boston, Mass., also by "Suggested Good Practice for Safe Loading and Discharging of Oil Tankers," published by the American Petroleum Institute, 250 Park Avenue, New York, N. Y.]

3. Outside above ground, vertical petroleum storage tanks.

[NOTE: Covered by a Manual on Cleaning Petroleum Storage Tanks published by the American Petroleum Institute, Department of Accident Prevention, 1508 Kirby Bldg., Dallas, Texas.]

4. Gasometers or Gas holders for natural and manufactured gas. It is recommended that the welding of gas holders be not attempted until such time as the American Gas Association has prepared a recommended procedure for such work.

5. Compressed gas cylinders.

General Methods of Treatment of Containers Covered by These Recommendations

1. The treatment of containers which have contained substances known to be soluble in water.

Flush thoroughly with water several times and fill with water as far as work permits, positioning container so as to permit introduction of as much water as possible. Proceed with repair work.

For example, an acid drum may be handled in this manner and the hazard of hydrogen production by the action of the acid on the metal eliminated. Care must be taken to remove all traces of acid since dilute acid frequently produces hydrogen when concentrated acid will not in contact with the same metal.

2. Treatment of containers of previously known content which is not water-soluble.

The most important class or type of container includes gasoline tank trucks, gasoline ground tanks up to 2000 gallons, domestic heating fuel oil tanks up to 2000 gallons and similar containers that have contained oil or gasoline. These comparatively small containers can be readily treated with steam or cleansing agent and filled with inert gas and repaired by exterior operations.

It is recommended that the inert gas method, herein described, be used in all cases, even when the containers have been steamed or treated with hot chemical solution previously. The presence of inert gas in sufficient quantity will prevent ignition or explosion of vapors driven out of seams and joints upon the application of heat and not removable completely by steam or chemicals. This treatment supplements, rather than supplants, existing methods such as steaming or treatment with hot chemical solution.

*General Precautions**

If the nature of the substance previously held by the container is not known, it must be assumed to be flammable and insoluble in water.

(*A*) Cleaning should preferably be done in the open, if in a building the room should be well ventilated so that flammable vapors will be quickly and safely carried away.

[NOTE: The vapors of most flammable liquids are heavier than air and tend to collect on the floor, in pits or other low spots unless adequate ventilation is provided.]

(*B*) All sources of ignition, such as open flames, unapproved light or power switches and unguarded electric lights, should be removed from the vicinity of the container, or rendered inoperative.

(*C*) The container should be emptied and drained thoroughly to remove as much of the content as possible. Removal of sludge and sediment may be facilitated by scraping or, in some cases, by rotating the container with a brass chain used as a scrubber. Hammering with a *wooden* mallet may help to loosen scale. Iron or steel chisels, scrappers or hammers should not be used because of the danger of sparks igniting flammable vapors. The residue should be immediately disposed of so it will not increase the hazard of the work.

(*D*) Containers divided into two or more compartments should have each compartment treated in the same manner regardless of what portion of the container is to be subjected to the welding or cutting process.

(*E*) Welding of containers should be attempted only by experienced welders, and under the direct supervision of some person familiar with the explosive characteristics of the contents.

(*F*) When welding or cutting keep the head and arms away from the head of the drum as far as possible. Repair leaks on the sides of the drum before repairing the head.

Approved Method of Inert Gas Treatment

The following procedure is applicable to all containers to which *these recommendations* apply *except* those having contained nitrocellulose or other pyroxilin plastics, aluminum or magnesium powders, carbon bisulfide, or materials which may decompose and release combustion-supporting agents and thus render inert gas protection ineffective.

Permissible gases include carbon dioxide and nitrogen. Carbon dioxide is generally available; it is heavier than air and will tend to remain in the containers during the welding or cutting operation.

Nitrogen, when available, is satisfactory. It is applied in the same way as carbon dioxide supplied in cylinders but the volume used must be at least 10% more than the volume of carbon dioxide specified herein.

Procedure

(*A*) Close all openings with exception of drain and vent. Damp asbestos, wood flour, adhesive tape or friction tape or similar material may be used for plugging cracks or other damaged sections.

(*B*) Fill container with water to overflowing and flush thoroughly, preferably admitting water through the drain. If no drain is provided, flush by running hose through vent to bottom of tank to secure agitation from bottom upward.

(*C*) Position tank when possible so that portion to be worked on is uppermost.

(*D*) Drain off water allowing as much as welding or cutting work permits to remain in the container and thus reduce volume of inert gas required.

(*E*) Introduce a sufficient quantity of carbon dioxide into the container to produce a concentration of not less than 50% by volume. This will usually require the introduction of a volume of inert gas at least as great as the volume of the gas space in the container since the inert gas may tend to flow directly out of the vent after displacing only part of the previously contained gases or vapors. In purging with carbon dioxide, it is recommended where possible and the strength of container permits that the inert gas be introduced to raise the pressure in container to 10 or 15 lb. per sq. in. Release of pressure from the container will promote turbulence and thorough ventilation.

[NOTE: When the carbon dioxide content is not less than 50% any mixture, regardless of ratio of flammable vapor to air, will be non-flammable and non-explosive, unless the flammable vapor is principally hydrogen or carbon monoxide in which case a minimum of 80% carbon dioxide content is required.]

It is permissible to use carbon dioxide gas compressed into cylinders or solidified carbon dioxide, commonly called "Dry Ice," handled commercially in cakes 10 x 10 x 10 in., weighing 50 lb.

1. Introduction of carbon dioxide gas from cylinders. When large volume of carbon dioxide is required, the rate of withdrawal of the gas from the cylinder can be increased without freezing the cylinder valve by inverting the cylinder. If nitrogen is used, cylinders should be used upright.

(*a*) Introduce carbon dioxide into container at low pressure, preferably replacing water. (See Fig. 1.) As water leaves drain, introduce equal volume of carbon dioxide through vent.

[NOTE: Calculate volume of container and introduce at least equal volume of carbon dioxide. To estimate volume of carbon dioxide withdrawn from cylinder, weigh cylinder before and after withdrawing gas and calculate volume withdrawn on basis of 8.5 cu. ft. per lb. If nitrogen is used, estimate volume withdrawn from cylinder by weighing cylinder before and after withdrawing gas and calculate volume withdrawn on basis of 13.7 cu. ft. per lb.]

(*b*) Where vent and drain are not present, introduce carbon dioxide through hose with outlet at bottom of tank so that heavier carbon dioxide forces other gases above it out of vent.

2. Introduction of carbon dioxide as solid.

(*a*) Crush the solid and shovel sufficient into container to produce volume of carbon dioxide gas to fill gas space. The solid should be scattered over the bottom in a thin layer to secure rapid evaporation.

[NOTE: 1 pound solid carbon dioxide will vaporize to 8.7 cu. ft. of carbon dioxide gas at 70° F. at atmospheric pressure. Introduce sufficient weight of solid carbon dioxide to provide volume of gas at least equal to calculated volume of container.]

(*F*) Determine whether sufficient carbon dioxide is present in container by taking samples from bottom and top of container and analyzing or testing all samples for explosibility.

1. Analyze samples chemically for carbon dioxide by means of Orsat or other approved gas analysis ap-

* Supplemental references: (1) "Handling, Cleaning and Filling Drums and Barrels," Industrial Safety Series—Petroleum No. 8—published by the National Safety Council, 20 North Wacker Drive, Chicago, Ill. (2) "Removing Flammable Vapors from Service Station Gasoline Storage Tanks," Industrial Data Sheet D—Petroleum No. 1—published by the National Safety Council. (3) "Regulations of the National Board of Fire Underwriters for Carbon Dioxide Fire Extinguishing Systems and Inert Gas for Fire and Explosive Prevention" as recommended by the National Fire Protection Association, 85 John Street, New York, N. Y.

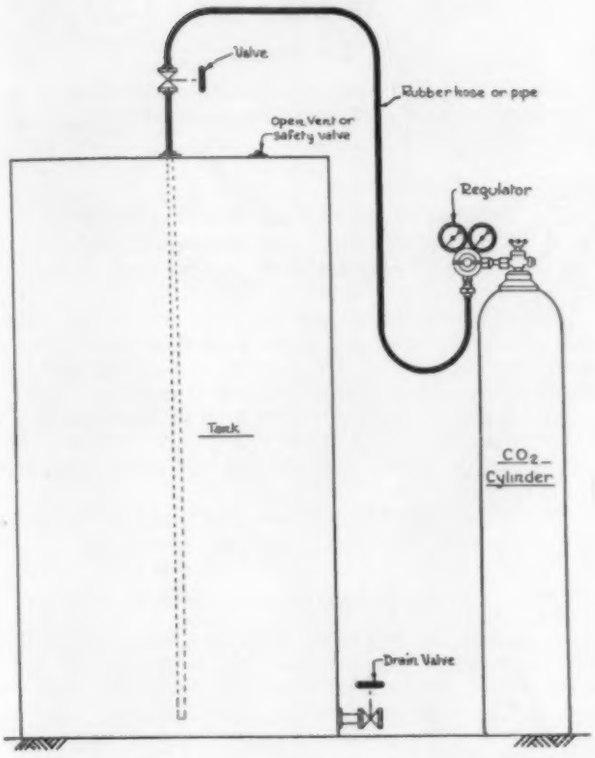


Fig. 1

paratus. Concentration of carbon dioxide found should be not less than 50% by volume in every sample.

2. At safe distance from container, test the sample for flammability by releasing small volume and exposing to flame. If the sample does not ignite or flash back, the container may be considered vapor free and safe for welding and for cutting operations.

[NOTE: The Larner gas sampling device is recommended. See Fig. 2 and Appendix A for directions for sampling and testing operations.]

(*G*) Take steps to maintain high carbon dioxide concentration.

1. If carbon dioxide is supplied from cylinders, continue to pass the gas at low pressure into container during welding or cutting operation.

2. If carbon dioxide is supplied in solid form, dump excess solid into container where it will vaporize during welding or cutting operation.

[NOTE: Avoid bodily contact with solid carbon dioxide. It will produce "burns." Avoid breathing large amounts of carbon dioxide. Do not tightly close a vessel which contains solid carbon dioxide as such will produce pressure.]

(*H*) Proceed with welding or cutting operation or other hot repair work.

Hot Chemical Solution Method

The chemicals generally used in this method are compounds of sodium silicate or tri-sodium phosphate (strong washing powder) dissolved in water to a concentration of from two (2) to four (4) ounces of chemical per gallon of fresh water.

(*A*) Close all openings in container with exception of drain and filling connection or vent. Damp asbestos, wood flour or similar material may be used for sealing cracks or other damaged sections to be repaired.

(*B*) Fill container with water to overflowing and flush thoroughly, preferably admitting water through the drain connection. If no drain is provided, flush by entering hose through filling connection or vent and lead to bottom of container to secure agitation from bottom upward, thus causing any remaining liquid, scum or sludge in the container to be carried upward and discharged by overflowing.

(*C*) Thoroughly drain container.

(*D*) Completely dissolve the amount of chemical required by size of container in small quantities of boiling water and pour into the container. Then fill container with fresh water.

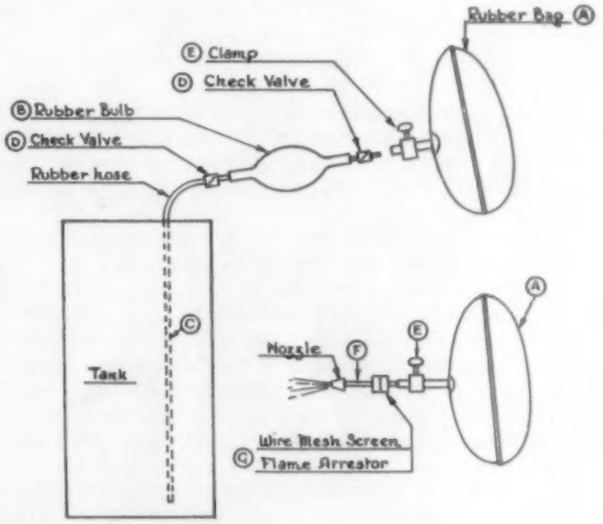
(*E*) Make steam connection to the container either through drain connection or by pipe entering through filling connection or vent and leading to bottom of container. Admit steam into the chemical solution and maintain solution at a temperature of 170° to 190° F. At intervals during the steaming, add sufficient water to allow discharge by overflowing of any volatile liquid, scum or sludge, that may have collected at the top. Continue steaming until no appreciable amount of volatile liquid, scum or sludge appears at the top of the container.

(*F*) Drain container.

(*G*) After draining, the container should be safe for welding, or performing any hot mechanical work, but as a matter of precaution, a sample of gas from the container should be obtained and tested, using gas sampler apparatus described in this report or other suitable equipment.

(*H*) If steaming facilities for heating the chemical solution are not available, a less effective method is the use of a cold water solution with the amount of cleansing compound increased to about six (6) ounces per gallon of water.

(*I*) In performing cleaning operations by this method, personnel should guard against injury from steam or caustic cleansing compound. Workmen should provide



APPARATUS FOR OBTAINING AND TESTING SAMPLES OF FLAMMABLE OR EXPLOSIVE GASES

Fig. 2

themselves with suitable goggles, gloves and other protective coverings.

Steaming Method

(*A*) Prior to steaming, fill the container at least twenty-five per cent full with hot soda or soda ash solution (1 lb. of caustic to a gallon of water), and agitate it sufficiently to insure that the interior surfaces are thoroughly flushed.

(*B*) Thoroughly drain the container.

(*C*) Close all openings in the container with the exception of drain and filling connection or vent. Damp asbestos, wood flour or similar material may be used for sealing cracks or other damaged sections to be repaired.

(*D*) Blow live steam into the container through drain preferably, or any accessible opening for a period of time to be governed by the condition or nature of the flammable substance previously contained. Do not steam a container with only one opening.

[NOTE: When steam or hot water is used to clean a container the operator should wear suitable clothing, such as boots, hood, etc., to protect himself against burns.]

1. Low pressure steam should be used. The steam line into the container should be steam hose of not less than $^3/_4$" in diameter, without nozzle or valve at the outlet end. The steam pressure shall be controlled by valve ahead of the hose.

[NOTE: If metal nozzle is used it should be of non-sparking material. It should also be electrically grounded to the container and the container should be grounded to prevent static electricity accumulation.]

2. The time of steaming should be continued until the container is free from odors and the metal parts of the container are hot enough to permit steam vapors to flow freely out of the container vent or similar opening. It is inadvisable to set a definite time for steaming containers, even of specific size, as weather conditions, such as rain or extreme cold, may condense the steam vapor as fast as it is introduced. It may take several hours to heat up the container to such a temperature that steam vapor will flow freely from the outlet of the tank.

(*E*) Thoroughly flush the inside of the container with boiling water and drain.

(*F*) Inspect the inside of the container to determine that it is clean. This may be done by using a mirror to reflect light into the vessel. If examination shows that the container is not clean, it should again be steamed and flushed with hot water.

[NOTE: Light source should be an electric lantern or flashlight approved for hazardous locations.]

(*G*) Inspect the container to determine if it is gas free. This test preferably should be made by means of a suitable gas detector. If unavialable, take a sample of the gas from the container with the Larner Gas Sampler as described herein, and test it for flammability. If the gas does not ignite or flash back the container may be considered as gas free and safe for welding and/or cutting operations.

(*H*) Before welding or cutting operations are started, position the container so that the portion to be worked on is topmost and fill as full of water as the welding or cutting work permits.

APPENDIX "A"

Gas Sampler

Description of necessary material, operation of and test of flammable and explosive gases with gas sampler apparatus.

Material Required

(*a*) Football bladder or small rubber bag.
(*b*) Rubber bulb pump (hand squeeze type).
(*c*) Ball type check valves (rubber tube type, two (2) necessary).

[NOTE: A rubber syringe equipped with check valves can usually be procured at any drug store. This will serve the purpose of the rubber ball pump and will eliminate the check valves as separate items.]

(*d*) Rubber tubing ($^1/_4$ to $^3/_8$ in. internal diameter).
(*e*) Rubber tubing clamp.
(*f*) Nozzle (metal construction, similar to glass tube eye dropper).
(*g*) Wire mesh flame arrester (100 mesh wire cloth, 0.0045 in. wire diameter, 0.0055 in. openings).

Operation of Gas Sampler

1. Install check valves in rubber bulb (*b*) so that one valve allows air to suck into bulb and the other valve allows air to discharge from the bulb when the bulb is operated by squeezing and releasing with the hand. Connect the suction end of rubber bulb (*b*) to rubber tubing (*c*).

2. Lower free end of rubber tubing (*c*) into container to the level at which the sample of gas is desired.

3. Operate rubber bulb pump (*b*) (squeeze and release by hand) a sufficient number of times to insure that all entrapped air is discharged and that these parts of the sampler apparatus are completely filled with gas representative of that in container.

4. Thoroughly deflate rubber bladder (*a*) and connect the filling tube of same to the discharge end of the rubber bulb pump (*b*).

5. Operate rubber bulb pump (*b*), fill and expand the rubber bladder (*a*) to a pressure sufficient to conduct test of the gas.

6. Seal rubber bladder (*a*) with clamp (*e*) and disconnect same from other parts of the sampler apparatus.

7. Connect nozzle (*f*) and flame arrester (*g*) to rubber bladder (*a*).

Test of the Gas

At safe distance from the container, apply flame of match, candle or torch to the tip of nozzle (*f*), and simultaneously release clamp (*e*) allowing gas to flow from the tip of the nozzle. If the flow of gas from the nozzle has a tendency to deflect or blow out the flame, the gas may be considered to be non-flammable and non-explosive and the contents of gas in the container sufficiently safe for accomplishing welding or other hot mechanical work.

If, however, the flow of gas from the nozzle has a tendency to ignite or flash back explosions occur, it *must* be considered that the gas content of the container is flammable, explosive and *unsafe* for performing any welding or other hot mechanical work on the container.

American Welding Society Bulletin on Symbols

Preface 1935 Edition

The Symbols shown in Figs. 1 and 2 are a revision of the Fusion Welding Symbols in the Society's Bulletin, "Welding and Cutting Nomenclature, Definitions and Symbols," which was published in 1929. The Revision was approved by the Main Committee on April 25, 1934, and by the Executive Committee of the Society on May 22, 1934.

It should be noted that:

(*a*) The Symbols are intended for use on drawings for all types of products and structures fabricated by fusion welding.

(*b*) Not only have the Symbols been found to be practical as the result of extended use, but they have been adopted as a standard by the various Bureaus of the U. S. Navy: the American Marine Standards Committee; all of the major Merchant Shipyards; several Machinery Manufacturers, Steel Fabricators, Architects and Engineers. They have also been incorporated in the Society's Code for Fusion Welding and Gas Cutting in Building Construction.

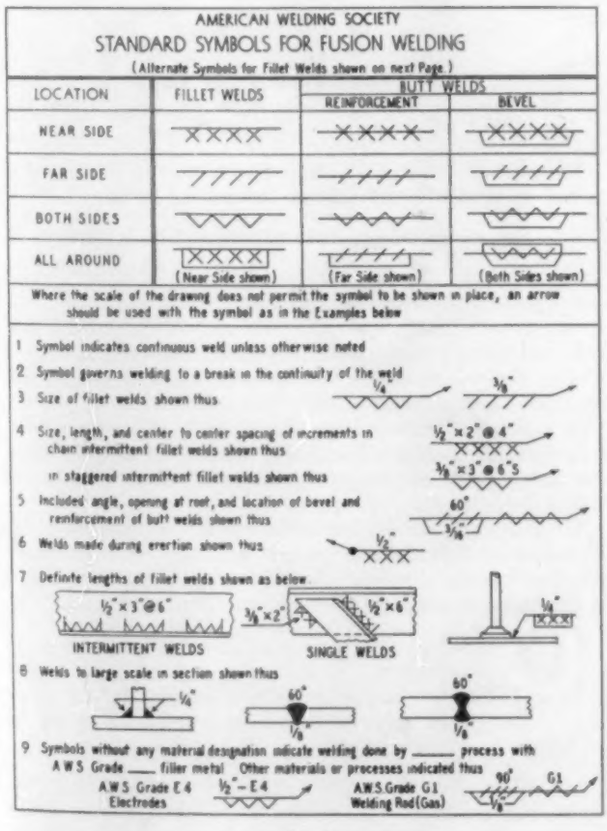

AMERICAN WELDING SOCIETY
STANDARD SYMBOLS FOR FUSION WELDING
(Alternate Symbols for Fillet Welds shown on next Page)
LOCATION
FILLET WELDS
BUTT WELDS
REINFORCEMENT
BEVEL
NEAR SIDE
FAR SIDE
BOTH SIDES
ALL AROUND
(Near Side shown)
(Far Side shown)
(Both Sides shown)
Where the scale of the drawing does not permit the symbol to be shown in place, an arrow should be used with the symbol as in the Examples below
1 Symbol indicates continuous weld unless otherwise noted
2 Symbol governs welding to a break in the continuity of the weld
3 Size of fillet welds shown thus
4 Size, length, and center to center spacing of increments in chain intermittent fillet welds shown thus
in staggered intermittent fillet welds shown thus
5 Included angle, opening at root, and location of bevel and reinforcement of butt welds shown thus
6 Welds made during erection shown thus
7 Definite lengths of fillet welds shown as below
INTERMITTENT WELDS
SINGLE WELDS
8 Welds to large scale in section shown thus
9 Symbols without any material designation indicate welding done by ____ process with
AWS Grade ____ filler metal. Other materials or processes indicated thus
AWS Grade E4 Electrodes
AWS Grade G1 Welding Rod (Gas)

Fig. 1

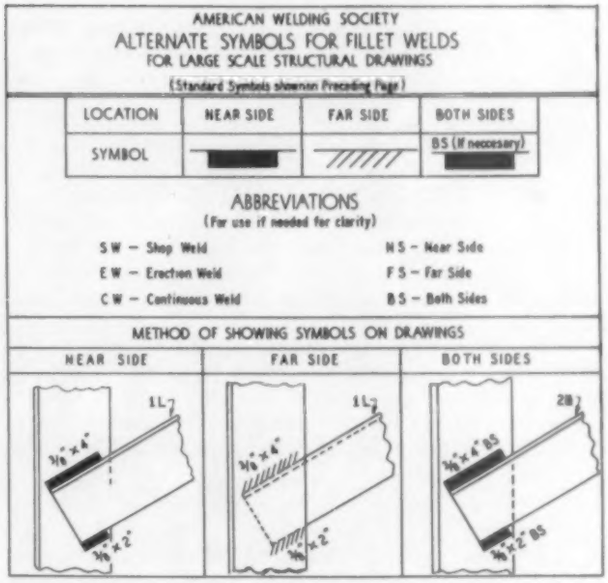


Fig. 2

Respectfully submitted,

J. W. Owens, Fairbanks Morse & Company (*Chairman*)
*L. C. Bibber, Bureau of Construction and Repair, Navy Dept.
W. S. Broberg, Ord. Dept. U. S. A.
*A. M. Candy, Westinghouse Electric & Manufacturing Company
H. W. Craver, Engineering Societies Library
J. J. Crowe, Air Reduction Sales Company
J. H. Deppeler, Metal & Thermit Corporation
F. M. Farmer, Electrical Testing Laboratories
Bureau of Engineering, Navy Department
H.O. Hill, McClintic Marshall Corporation
*F. T. Llewellyn, United States Steel Corporation
H. M. Priest (*alternate*), Railroad Research Bureau
G. H. Moore, Jr., Newport News Shipbuilding & Dry Dock Company
*H. H. Moss, Linde Air Products Company
H. W. Samson, Data Section, Pub. Dept. General Electric Company
W. Spraragen, American Bureau of Welding
*A. Vogel, General Electric Company
H. A. Woofter, Swift Electric Welder Company

Committee on Nomenclature, Definitions & Symbols

* Sub-Committee on Revision of Symbols, L. C. Bibber, *Chairman*.

American Welding Society Marine Code for Welding and Gas Cutting—Part D

Rules for the Fusion Welding of Hulls and Hull Parts

AMERICAN WELDING SOCIETY

Introduction

This Part of the "Marine Code for Welding and Gas Cutting" outlines the best commercial practice in the application of Fusion Welding and Gas Cutting to the construction of Hulls and Hull Parts of merchant ships.

The Main Committee and the Board of Directors of the Society desire to express their appreciation to the Hull Sub-Committee, for the successful completion of this Part of the Code.

It was *approved* by the Main Committee on April 25, 1934, and by the Board of Directors of the Society on Sept. 1, 1934.

The folowing is the personnel of the Committee on Welding in Marine Construction, as constituted April 25, 1934:

James W. Owens, (*Chairman*), National Weld Testing Bureau, Pittsburgh, Pa.
*David Arnott, American Bureau of Shipping, New York
*L. C. Bibber, Bureau of C. & R., U. S. Navy Dept., Washington, D. C.
*C. W. Bryan, Jr., Federal Shipbuilding and Dry Dock Co., Kearny, N. J.
*E. H. Ewertz, E. H. Ewertz & Sons, New York
E. R. Fish, Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.
*A. J. Grassick, United Dry Docks Inc., New York, N. Y.
D. S. Jacobus, Babcock & Wilcox Company, New York, N. Y.
*G. H. Moore, Jr., Newport News Shipbuilding and Dry Dock Co., Newport News, Va.
C. W. Obert, Union Carbide & Carbon Research Laboratories, Long Island City, N. Y.
*K. Schested, New York Shipbuilding Corporation, Camden, N. J.
H. W. Pierce (*alternate*)
*J. W. Wilson, Bureau of Navigation and Steamboat Inspection Service, Washington, D. C.
*H. A. Woofter, Swift Electric Welder Company, Detroit, Mich.
*J. H. Deppeler, Metal & Thermit Corp., New York

D. S. JACOBUS, *President*,
AMERICAN WELDING SOCIETY

August 4, 1934

D-1 Processes

1. Hulls and hull parts of merchant vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications outlined herewith.

Definitions

The definitions of welding terms, as approved and published by the AMERICAN WELDING SOCIETY, shall govern any welding terms appearing in these Rules. For convenience, some of the most common terms have been included herein, and their specific application under this Code is defined as follows:

(*a*) *Fusion Welding.*—A process of welding metals in the molten or molten and vaporous state without the application of mechanical pressure or blows.

(*b*) *Fillet Weld.*—A fusion weld of approximately triangular cross section whose throat lies in a plane disposed approximately 45 deg. with respect to the surfaces of the parts joined.

The size of a fillet weld shall be expressed in terms of the width in inches of both adjacent legs if unequal, and of one leg if equal.

See Definition for "Leg."

(*c*) *Butt Weld.*—A weld whose throat lies in a plane disposed approximately 90 deg. with respect to the surfaces of at least one of the parts joined.

The size of a butt weld shall be expressed in terms of its net or unreinforced throat dimension in inches.

(*d*) *Leg.*—One of the fusion surfaces of a fillet weld.

(*e*) *Throat.*—The minimum thickness of a weld along a straight line passing through the root.

(*f*) *Root.*—The zone at the bottom of the cross-sectional space provided to contain a fusion weld.

(*g*) *Toe.*—The edge of a fusion weld formed by the intersection of a face and the base metal.

(*h*) *Double-Welded Butt Joint.*—A joint formed by the fusion of two abutting edges with filler metal added from both sides of the joint and with reinforcement on both sides.

(*i*) *Single-Welded Butt Joint.*—A joint formed by the fusion of two abutting edges with all the filler metal added from one side of the joint with a reinforcement on the side from which the filler metal is added.

A joint with filler metal added from only one side is considered equivalent to a double-welded butt joint when and if means are provided for accomplishing complete penetration and reinforcement on both sides of the joint.

(*j*) *Weld Length.*—The length of a weld shall be considered to be the unbroken length of the full cross section of the weld exclusive of the length of any craters.

* Members of Hull Sub-Committee, Mr. C. W. Bryan, Jr., *Chairman*.

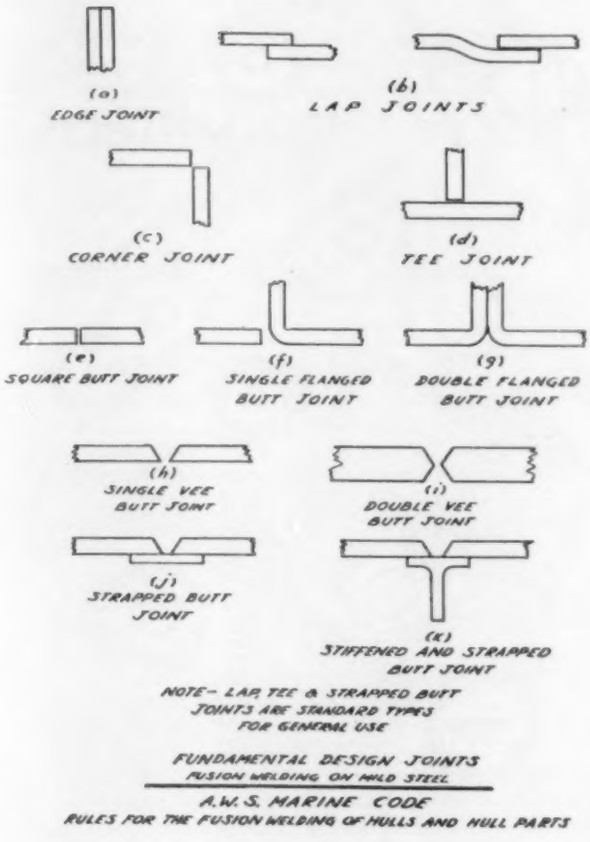


Fig. 1

D-2 Material

(*a*) *Base Metal*

1. The grade of steel for the plates and shapes under this Code shall conform to A.S.T.M. A-131–31–T for structural steel for ships. If, in the development in the art of welding, other materials than those herein described become available, specifications may be submitted for consideration.

(*b*) *Filler Metal*

1. The filler metal used for all strength joints shall be capable of providing welds having the minimum joint and deposited metal requirements specified in the current Specifications of the AMERICAN WELDING SOCIETY Specifications for Filler Metal for Use in Fusion Welding except as noted in paragraph *b*-2. If the process requires no filler metal, the joints shall develop the requirements of these Specifications.

2. The filler metal used for mild steel may be divided into two classes and shall have at least the following deposited metal physical properties without heat treating or stress relieving. These properties shall be determined from a deposited weld specimen as shown in the Filler Metal Specifications, referred to.

Property	Welding Class I	Class II
Ultimate tensile (lb./in.²)	60,000	54,000
Elongation (minimum) in 2 in.	(0.505 in. dia.) 20%	7%

D-3 Design

(*a*) *General*

1. Welded joints and connections shall conform to the fundamental designs given in Fig. 1.

2. Complete details of all welding shall be clearly shown on all drawings, or plans, by means of the approved nomenclature and symbols of the AMERICAN WELDING SOCIETY. The class of weld metal used shall be specified and shown on the drawings.

3. Joints shall be designed and located so as to facilitate the obtaining of complete and satisfactory fusion and root penetration.

4. Careful consideration shall be given to the prevention of excessive stress concentrations occasioned by welding.

(*b*) *Design Values*

Design values based on filler metal properties defined in Section D-2*b*, shall be as follows with a suitable factor of safety.

Design	Class I	Class II
Ultimate Stress	Pounds per Square Inch	
Tension	45,000	36,000
Compression	45,000	36,000
Shear, pure	36,000	29,000
Parallel shear	31,500	25,500

D-4 Workmanship

(*a*) *General*

1. Care must necessarily be taken to insure that all welds, including tack welds, made in production shall be made with filler metal which will produce welds having the properties stated in D-2*b* in association with values within the limits given in D-3*b*.

2. Welds shall be sound, thoroughly fused to the base metal, have a regular and uniform surface contour and be reasonably free from overlap, undercut, cold shuts and gas pockets. Welding so finished shall not require any form of dressing, peening, roughing or similar finishing process.

3. Surfaces on which weld metal is deposited shall be free from loose mill scale, excessive rust, paint or other foreign matter excepting galvanized zinc coatings of ordinary thickness. A thin coat of linseed oil, or equivalent, need not be removed before welding. Slag and scale shall be removed from each layer before deposition of the subsequent layer.

4. Welding shall not be done on joint surfaces when they are wet, excessively oily or greasy.

5. Unsatisfactory welding shall be corrected by removal and rewelding.

(*b*) *Test Requirements for Operators of Welding Equipment*

1. Before being assigned to welding permitted under these rules, each operator of welding equipment shall demonstrate his ability to do satisfactory work, using the contractor's standard equipment, materials and practice by welding the necessary weld specimens shown in Fig. 2. The minimum ultimate tensile strength of any specimen shall be:

For Class I Filler Metal—60,000 lb./in.² and
For Class II Filler Metal—54,000 lb./in.²

The method of testing the Free Bend Test specimen shall be as specified in the A. W. S. Filler Metal Specifications. The minimum Free Bend Test Elongation of any specimen shall be:

For Class I Filler Metal—20% and
For Class II Filler Metal—7%

2. Test plates shall be welded and tested in the presence of accredited inspectors, who shall sign a suitable report.

3. The tests of each operator of welding equipment shall be made by the contractor. Three months lapse of welding employment shall require retesting. The contractor shall have the operator of welding equipment repeat the test whenever there is a change of welding process or where there is reasonable doubt of the operator of welding equipment's ability to produce efficient welds.

Tests made by one contractor shall not permit the operator of welding equipment to do welding for another contractor without retesting.

Tests shall not be required for tack welding on assembly or erection work, or for apprentice welding on parts where structural strength and/or tightness is not involved.

Base and filler metal used for tests shall be that specified in Section D-2. If materials are to be used other than those permitted under D-2, the contractor shall be required to make special tests of the operator of welding equipment.

The contraoctr shall maintain a permanent record of the operators of welding equipment employed by him, showing the date and results of tests and the identification marks assigned to each. These records shall be certified to by the contractor and shall be accessible to the inspector.

D-5 Erection

1. The sequence of assembly and the procedure of erection and welding shall be such as to minimize residual stress in the finished structure.

2. Where unavoidable clearance exists between contact surfaces the size of the fillet weld shall be increased by the amount of the clearance.

D-6 Safety

1. Precautionary means shall be taken to provide for the safety of the operator of welding equipment, other employees, the structure and other property.

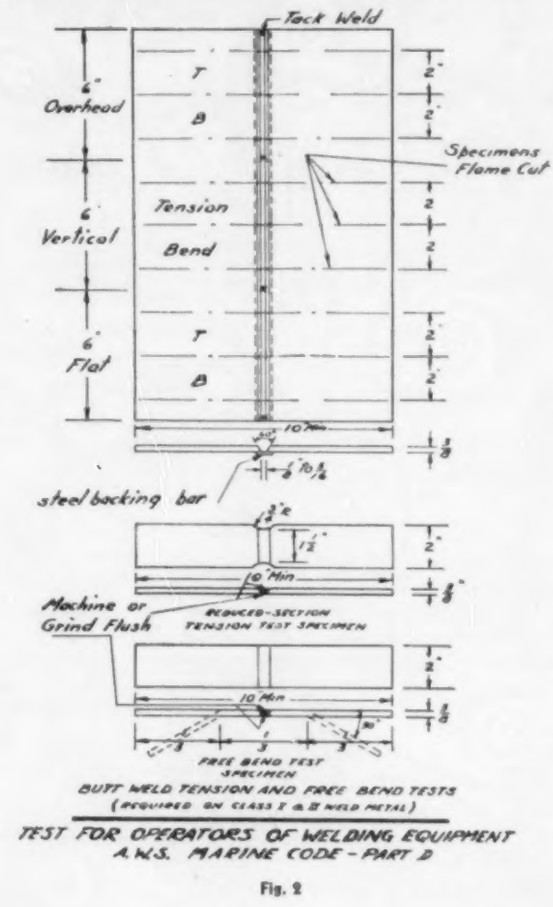
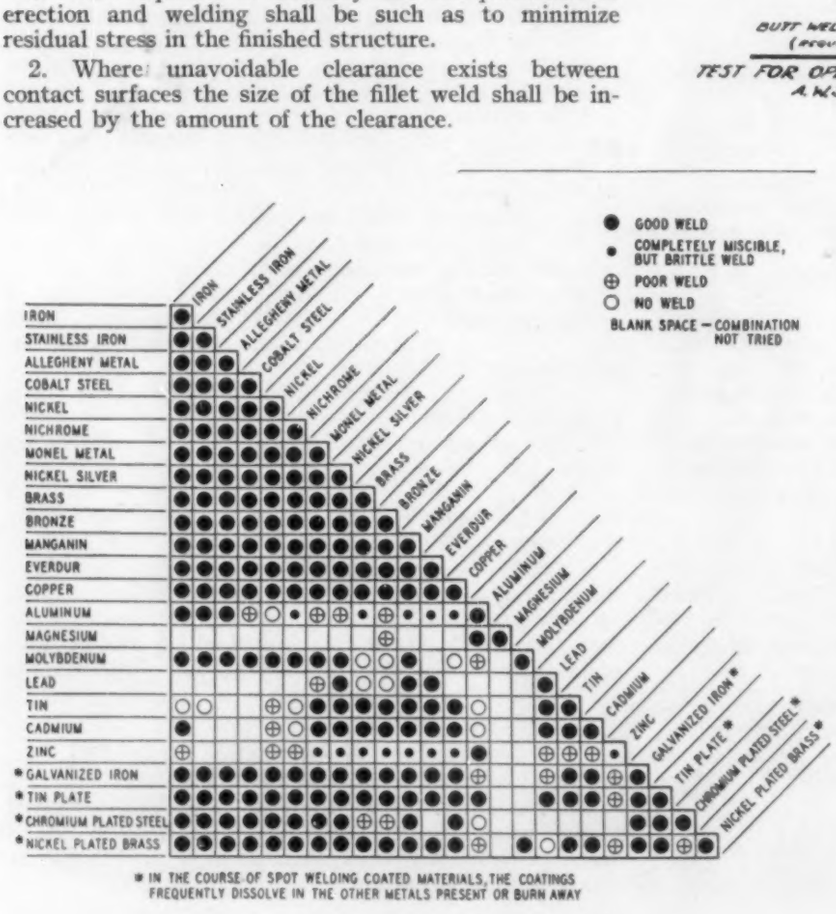


Fig. 2



Spot Welding

Characteristics of spot welding of some 250 combinations of metals. This study was made by Lawrence Furguson of the Bell Telephone Laboratories, Inc. As in spot welding of steel, an essential detail is the choice of a suitable electrode tip. For welding high resistance materials such as iron, nickel, nichrome and nickel-silver, electrode tips of copper are suitable. Where greater strength or longer life is required, however, a copper-rich copper-tungsten alloy is advisable. For low resistance materials such as copper or aluminum, tungsten tips are the best, as they do not easily alloy or weld at ordinary welding temperatures.

Qualifying Welding Operators for Structural Work*

By GILBERT D. FISH †

A SINGLE comprehensive examination of a professional engineer may prove his knowledge and experience sufficiently to justify placing him in charge of work involving safety of persons and property. In the absence of later signs of mental or nervous disability or dangerous habits, his fitness for such responsibility may be assumed to continue indefinitely. Periodic re-examination is considered unnecessary.

In judging the qualifications of operators of welding equipment, skill and dependability cannot be regarded as permanent. The skill is manual rather than mental and the dependability is greatly affected by health, continuity of employment and other factors subject to change. It would be dangerous to borrow the idea of permanent qualification from professional engineering and apply it to welding operators.

Extensive unemployment among welders, especially in the structural field, has for several years caused some difficulty in examining candidates for jobs. When a man is tested for a job which he badly needs, after being out of work and therefore out of practice for months or perhaps years, his loss of skill is aggravated by anxiety and he is likely to make a showing which does not do him justice. A wise inspector recognizes the trouble and gives the welder plenty of opportunity to practice on scrap steel before making specimens to be tested for record.

The popularity of strength tests as criteria for qualifying welders is due mainly to their definiteness. They furnish numerical records to be exhibited and filed away, and are a blessing to those who are unable to judge welding performance by watching it but who must nevertheless conduct examinations without the aid of expert inspectors.

The most experienced welding supervisors rely more on watching performance than on laboratory tests of breaking strength. It appears doubtful whether any one, who has not had considerable experience as an operator or at least a good deal of practice making welds, can be thoroughly competent as a judge of welds. Experience in making welds does not alone make a good inspector, because the critical faculty must be developed.

A practical procedure for qualifying arc welders for structural work is the following: Let each candidate weld several specimens like Fig. 1 in presence of an experienced inspector, the latter noting length of arc, angle of electrode, manipulation, depth of crater, sound of arc, amount of spattering, if any, irregularities, such as breaking of arc or sticking of electrode and average meter readings. The inspector later notes the appearance of the finished welds, with special reference to uniformity, shape of exposed surface, overlap, under cutting, porosity and excessive oxidation. The welds after cooling are broken by hammering the plates in such manner as to bend the welds as indicated by Fig. 2. The angle of bend at which a weld breaks is an index of ductility and the appearance of the fracture affords important information as to structure of weld metal, penetration and presence of holes and slag inclusions. A diagonal break entirely within the weld metal is a characteristic of a satisfactory weld with most kinds of filler metal and is usually made a requirement. Although this test is qualitative and is recorded without use of figures, it provides definite grounds for classifying welds as to soundness of weld metal, completeness of fusion (including the important item of penetration at

* Paper presented at Fall Meeting, A. W. S., New York, October 1–5, 1934.
† Consulting Engineer, New York.

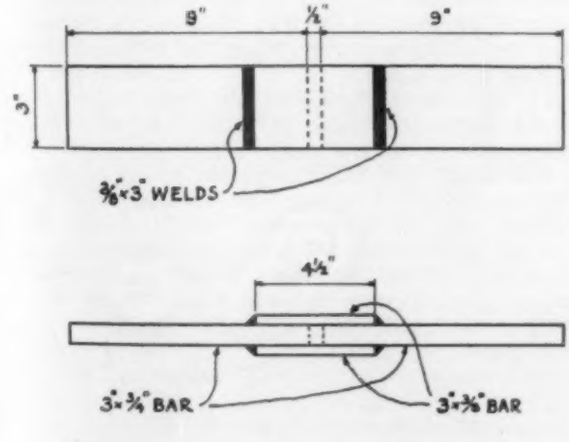


Fig. 3

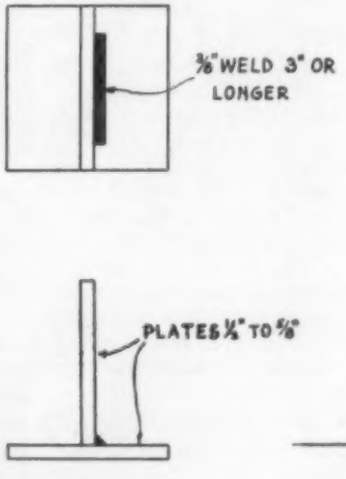


Fig. 1

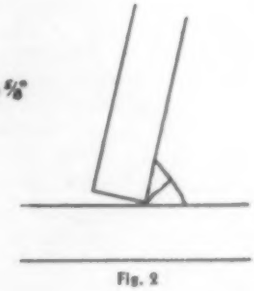


Fig. 2

the root) and undercutting. It is usual to require each operator to weld separate specimens in flat and vertical welding positions, and also in overhead position if overhead work is to be required.

This test, commonly called a *T-break test*, yields so much information and takes so little time, that its repeated use for every man at intervals of a few days during progress of a job affords a high degree of protection at slight cost. Even though it does not give direct numerical data on strength, any weld, which meets this test beyond doubt according to the judgment of an experienced inspector, is strong enough for complete safety at stresses within allowable design values, even though such a weld might have slightly lower strength than required by the test next described.

Figure 3 is a drawing of a strength-test specimen, proposed by the Structural Steel Welding Committee in its 1931 report and adopted by the Sub-Committee on the Revision of Code 1, Part A of the AMERICAN WELDING SOCIETY, in its report now before the Committee on Building Codes. The fillet welds, which are nominally $^3/_8$ in. in size, are required to be everywhere within $^1/_{16}$ in. of this size in each direction and their exposed faces must be reasonably flat or slightly convex. The specimen is tested in a tensile testing machine having at least 100,000-lb. capacity and is required to show an ultimate strength of 80,000 lb. or more in order to be accepted. The stress in the welds is a combination of tension and shear, although the load applied by the machine is tension only. The welds should break diagonally, approximately along the throat plane, as in the case of the T-break test. The required strength is 13,300 lb. per lin. in., which is 4.44 times the design stress permitted by the Building Code.

Another form of specimen, which has been used with satisfaction in practice, tests four instead of two welds, of the same cross section but half the length, in longitudinal shear. This direction of stress represents more truly than the other the usual duty of welds in framed structures, but the form of specimen is less convenient than the other because it requires careful measurements of the welds as to cross-section dimensions and also lengths. When the longitudinal-weld specimen is used, it is usual to accept a lower ultimate strength than for the transverse test, ordinarily 72,000 lb., because fillet welds are generally weaker in longitudinal than in transverse stress. The transverse test, in addition to being the more convenient, is somewhat more sensitive to flaws and other items of non-uniformity, and hence is more informative as to the degree of uniformity of the operator's welding.

It is common practice to require each operator to pass a T-break test and a strength test for each position of welding required in the proposed work, before accepting him for the job in view. Although it is usual to test in flat and vertical positions even if one of these positions is not expected to be used, it is not, as a rule, considered necessary to test in the overhead position if no overhead welding is to occur. Operators who pass both kinds of test at the beginning of a job are not ordinarily required to pass the numerical strength tests again during progress of the job, but it is customary on regularly inspected work to repeat the T-break tests every few days to discover evidences of decrease in skill.

It is not needful or customary to reject a candidate for qualification because of one or two failures to produce satisfactory specimens, unless his performance is so poor that he is unlikely to pass even after repeated attempts. A man's experience should be given weight in deciding whether to reject him on the basis of several unsatisfactory tests, because no quick examination can tell the whole truth about his ability. Some welders are temperamentally incapable of doing their best work on tests, whereas others who can perform impressively under examination are erratic or careless in routine work.

It can hardly be overemphasized that qualification and re-examination of operators make up only one phase of safety control in supervising welding operations. Inspection, which is not included in the topic of this symposium, is the other phase. The two must be planned and organized to supplement each other; they can scarcely be separated. An important part of inspection is to watch every operator in action at short intervals, but this is also part of the work of re-checking qualification. There are strong reasons, based more on experience than on research, for believing that frequent observation of performance is more important than any examination in advance. Another observation, based on considerable practice in welded-building construction, is that the judgment of a trained supervisor is a better guide to a welder's ability than quantitative strength tests.

It may be advisable to explain why fillet welds rather than butt welds are now favored both for qualitative fracture tests and for quantitative strength tests in structural work. The main reason is that an overwhelming majority of welds for structural purposes are of the fillet type, butt welds being economical only in special cases which do not frequently occur. Less obvious reasons are based on convenience and economy. If one plate were butt welded to another for the purpose of an informal fracture examination corresponding to the T-break test, it would be difficult or perhaps impossible to break the weld by hammering the plates. Again, the old-style butt-weld tension test requires cutting and machining the test specimens before and after welding, thus involving delay and extra expense.

The cost of qualifying structural welders by the methods described consists mainly of indirect expense, such as travel and time on the part of the supervisor and delays in starting shop work and field work while conducting the tests and waiting for laboratory reports. The direct expenses, such as material and workmanship for test specimens and laboratory fees, are slight. The so-called direct expenses are unlikely to exceed $10 per candidate, assuming three T-break specimens and three laboratory tests. The cost of organizing and supervising the tests may greatly exceed this figure, especially if the contractor fails to assemble enough candidates at once to provide for the whole job in one operation. It can readily be seen, for example, that if ten candidates report on three different days, requiring three visits by a supervisor from a point 100 miles distant, the expense of the outside supervision plus the time of the contractor's executives may easily amount to $150, to be added to about $100 direct expense for the specimens. If the examinations interrupt the contractor's routine and delay the job several days, these other indirect losses may be far more serious than the items already mentioned. On the other hand, if the examinations are arranged properly, ten candidates may easily be examined in one day and their laboratory specimens tested in two hours, without delaying the job at all and at a total cost somewhere in the neighborhood of $150.

A firm of engineers, undertaking to pass on the qualifications of a contractor's welding operators for a fixed fee, runs a risk of loss in case enough candidates and test plates to meet job requirements are not assembled at one time.

Use of Polarized Light as Applied to Welding Products*

By E. W. P. SMITH†

MODERN competitive conditions require, in fact demand, from any product satisfactory performance and adequate service life.

These qualities must be obtained at a cost low enough to permit a selling price which will obtain sufficient sales so that the article may be profitably manufactured.

It is the question of cost, as it affects the sales and service of the product, which is of vital importance to the manufacturer.

Under our present economic conditions, labor and material costs are being most carefully studied.

Material must be used most efficiently, always keeping in mind the service and performance of the product.

In the performance of the product, it is subjected to certain stresses, sometimes these are accurately known, sometimes they are not.

These stresses are of three general kinds: tension, compression and shear. Usually these occur not as single pure stresses, but as combinations of these three. Even a rather complex combination would be fairly simple if the load conditions were fixed or static, and if the stresses were uniformly distributed.

Most load and, therefore, resulting stresses are not static but are varying; and the stresses are not evenly or uniformly distributed.

The varying load causes stresses which vary. If these variations are repeated a great number of times, steel will fail at a unit stress value considerably below the elastic limit.

As an example, a steel 0.49% carbon with ultimate of 91,500 lb. per sq. in. and elastic limit of 44,700 under complete reversal of stress of 33,000 lb. per sq. in. did not fail. When this was increased to 34,000 lb. per sq. in., the test piece of same material failed at 4,000,000 reversals as compared to 100,000,000 reversals at 33,000 lb. per sq. in. and no failure (Bull. No. 136, Eng. Exp. Sta., University of Illinois).

The above was for complete stress reversal. If the stress is not completely reversed then the fatigue limit is of greater value.

The steel mentioned above, when subjected to unit stress of 36,000 lb. tension to 21,600 lb. compression, from 47,000 lb. tension to zero, from 60,000 lb. tension to 12,000 lb. tension, from 69,000 lb. tension to 34,500 lb. tension, stood indefinite number of repetitions of stress. (Boyd, Strength of Materials, p. 347).

In designing for these variable stresses, Prof. John Goodman (Mechanics Applied to Engineering) has suggested:

"Add to the maximum load the difference between maximum and minimum loads and treat as a static load."

As an example: 12,000-lb. tension to 12,000 compression would be treated as 12,000 + (+12,000) − (−12,000)) or 12,000 + 24,000 = 36,000 lb. tension or compression.

It has been suggested (Bulletin 136, University of Illinois Experimental Station) that the following formula be used, as being more accurate, Goodman's formula being very safe:

$$Sr = S_{-1}\frac{(r+3)}{2}$$

r = ratio minimum stress to maximum stress
Sr = endurance limit for ratio r
S_{-1} = endurance limit for complete reversal
S_{-1} must be determined experimentally

It is further stated that "this formula can be used only up to the limit at which the maximum unit stress set up reached the proportional elastic limit of the material and for most steels this eliminates ratios of minimum stress to maximum stress greater than zero. Beyond the proportional elastic limit the static properties of steel are the governing factors rather than the fatigue values."

From the above discussion it is obvious that the determination of the maximum stresses as they actually exist in the product or proposed design is of vital importance. It is exceedingly rare to have a failure, in which the piece or part failing "necks down" in the familiar way as shown in the usual tensile test.

The determination of the stresses and their distribution is therefore of vital importance. This may be done in several ways.

The use of the polariscope is one of the most convenient methods. The method is based upon the fact that when polarized light passes through an isotropic substance (equal properties in all directions) such as celluloid, bakelite, and that substance is stressed, the location of stress will appear colored when the rays are viewed through suitable mechanism.

Such a mechanism for studying stresses may be very elaborate and costly or relatively simple and low in cost.

The more elaborate method is the use of Nicol prisms and the lesser one by use of common glass.

Light may be looked upon as a series of transverse vibrations much the same as a stretched wire vibrates, when struck. There is this difference, however, that light vibrates in all planes and the wire in a single plane.

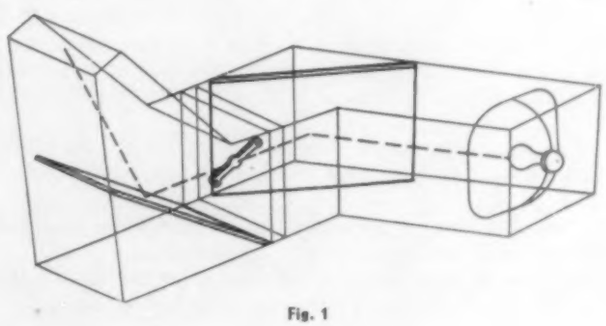


Fig. 1

* Paper presented at the Fall Meeting, A. W. S., New York, October 1–5, 1934.

† Consulting Engineer, The Lincoln Electric Company, Cleveland, Ohio.

If the light can be made to vibrate in a single plane, in same manner as the wire, then the light is plane polarized.

It has been determined experimentally that certain crystals have the property of polarizing light into two rays with these resultant rays at right angles to each other. Iceland Spar is one. This is non-isotropic, that is, it has different properties in different directions.

In general the action is as follows:

Two crystals of Iceland Spar of suitable shape are cemented together by Canada Balsam. This is the Nicol prism.

When common light strikes the crystal it is broken into two rays at right angles to each other, one vertical and one horizontal. The vertical plane of light travels faster and is deflected through a smaller angle than the horizontal which travels slower and is, therefore, deflected at a greater angle.

If the plane of the joint between the two crystals is at the proper angle, the vertical polarized ray will pass through and be deflected back parallel to its first direction. The other ray is deflected to the side and is absorbed in the blackened side of the enclosure. If the plane polarized light from this first prism is passed through a second in the same way, it will be unchanged. If the second prism is rotated 90° the ray will be reflected to the side and light does not pass through.

Materials such as celluloid and bakelite, when stressed, act exactly as Iceland Spar. Any beam of light is broken into two plane polarized rays, which vibrate parallel to the two principal stresses at any point in the material.

If the beam strikes the material normal to its surface, so neither ray is deflected through any angle, one ray having higher velocity than the other, one ray will emerge slightly ahead of the other. The amount one ray will emerge ahead of the other depends on the difference between the two principal stresses $(P - Q)$ and is, therefore, proportional to the shear. If this difference is a number of full wave lengths, the two combine, resulting in a beam the same as the original. If the difference is an odd number of half wave lengths this is not true and the resulting beam vibrates at right angles to the original.

If a sample to be studied is placed between two Nicol prisms, at right angles to each other, suitably lighted, and the difference in principal stresses is of such value as to cause rays to emerge one-half wave length apart, a light spot will appear on the screen, full wave length apart, a dark spot, one and a half wave lengths, a light spot, and so on. If light of all wave lengths is used, then the bands will show colors of the spectrum, instead of light and dark spots.

The colors thus shown indicate stresses. These may be calculated, but for comparing designs and locating stress concentration points this is usually not necessary. A bunching of the color lines indicates stress concentration.

Another and less costly type of polariscope is the box type.

It (see Fig. 1) consists of a light source, such as a $7^1/_2$ watt-point source of light, placed in a parabolic reflector; an automobile reflector cut to fit the box is excellent. The lamp should be located in the reflector so as to focus its rays.

The polarizing mirror may consist of several sheets of thin glass, or just a single piece, with the back painted black.

This polarizer is located so that the rays of light strike it $57^1/_2$ deg. from normal, or 90 deg.

This angle is a function of the index of refraction. For the usual glass it is approximately $57^1/_2$ deg.

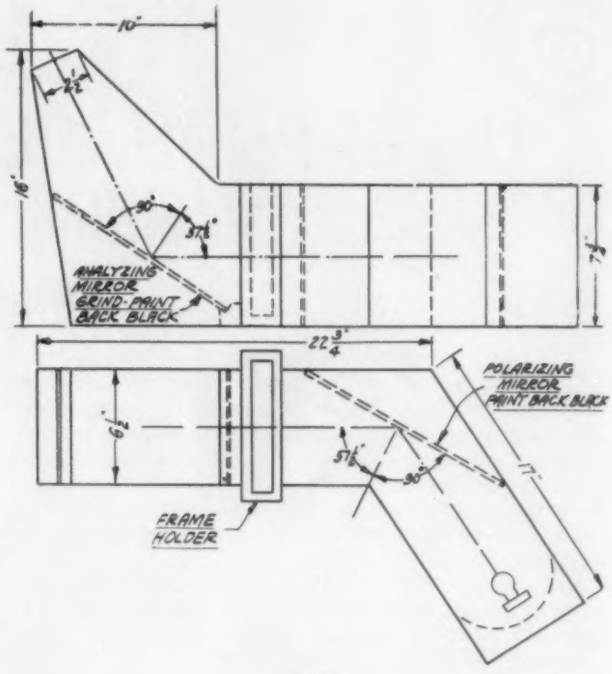


Fig. 2

The analyzer is a single piece of glass, ground and painted black on the back, so located that the rays from the polarizer impinge at $57^1/_2$ deg. from the normal. These rays are reflected through a suitable observation opening. Specimens made of bakelite or celluloid, cut to desired shape, are placed in a frame. This frame is so constructed that the specimens may be subjected to tension or other types of loading. The frame is inserted between the polarizer and analyzer and at right angles to the light rays.

All of the above items are held in place by a box. This may be of any material, the inside being given a flat black finish.

Where greater convenience of portability is desired the tye piece may be omitted and the box made in two parts, divided at the frame holder which is omitted. The frame is held between these two parts when they are suitably placed.

A convenient size is a box of $6^1/_2$ in. by $7^3/_4$ in. outside dimensions, using $^1/_4$-in. Plywood. This permits a good size model with reasonable dimensions of the box. (Fig. 2.)

In addition to the polariscope itself, models and a suitable frame for holding these models are needed. It is advisable to make a frame which is suitable for testing both tension and bending specimens.

First must come a study of pure tension. Two hooks are placed in the opposite corners of the frame and are so formed as to receive the model and permit its easy removal. They should be made of a type which will assure of the model being held straight and the center of pull exactly in line with the center of the model. This makes it easy to insert and remove the model, avoids bending and assures proper tension.

One of the hooks is stationary, while the other is fitted with screw or lever arrangement so it may be moved, and thus put the desired tension stress on the model.

Lever arrangements have the advantage that weight may be used and the actual total tension on the specimen determined. The same thing can be done by putting an

ordinary spring scale in series with the specimen, but this is not so conveniently done from a constructive viewpoint. The scale and parts necessary for holding it take up a great deal of room.

To make bending investigations of the simple beam type, it is necessary to provide two points of support and a load point. The load may be applied by direct loading from a rod, threaded and inserted in the corner of the frame, or it may be applied by a saddle and the load applied as a pull or weight hung underneath the beam.

The frame may be made of any material provided it is strong enough. Plywood makes a light, easily handled frame. The supports for the beam should be slotted so as to make it easy to hold it in place. The degree of concentration of load or point of application may be governed by shape and size of the saddle.

The specimens or models may be made of celluloid or bakelite. For the polariscope as shown in the drawings a convenient thickness is 0.178 in. The material used *must be of uniform thickness*. This uniformity is exceedingly important, but the actual thickness is not, provided the specimens are properly proportioned so that they do not bend or crumple when loaded.

Another very important point is that the specimen be of uniform width except where the model dimensions call for different dimensions. And the center line of the specimen must be on the center line of the holes for the hooks. This is to avoid bending and consequently inaccurate or misleading results.

When making the specimens it is advisable to use a drill jig, as the drill is very liable to drift; the sample will be out of line and the results or deductions in error.

Do not mark the surface of the material unless the mark is on a part which will be removed. For example, a center line scratched down the center of the sample would not be advisable. A line scribed as a limit, such as the edges of the sample and to which the material is cut, would be permissible, because when the material is cut the line is removed. It must be kept in mind that if reasonable, informative results are to be obtained, disturbing or unknown conditions must be kept at a minimum; and, as will be pointed out later, an interruption of the surface is a most disturbing condition.

Before proceeding to make a number of samples, it is well to make up a simple, pure tension sample.

A rather easy way to make these samples or models is to lay them out accurately on a piece of paper. Paste or glue this paper on the celluloid. Extend the center line of the sample so that when the jig is placed on it, the center line of jig, as marked on ends, can be easily lined up with the center line of the model.

Clamp the jig in position and drill the holes. Remove jig and cut out the model, smoothing the edges—a file or sandpaper will do. A saw with small blade, such as jig saw, is very helpful in cutting the sample, particularly the more complicated ones such as will later be described.

Place the sample in the frame and without putting any stress on it place it in the polariscope. By looking in at the observation opening with light on, there will be found a reflection of the piece in the analyzer. If the polariscope has been properly assembled, this will be a rather dark gray and, while the image will be clear, it will not be particularly or brilliantly illuminated. Now put some tension on the sample and watch carefully the first color. This will, in the case of celluloid, be yellow. After yellow will come orange, then red, changing to violet, to blue, to green. Now increase the tension still more and the sample will turn yellow again. This is the beginning of the second series of colors and upon a further increase of tension the sample will go through the colors of the spectrum in the same order as before. In some cases the second series may be completed and the third started without damage to the model.

Upon removing the stress the colors will appear in reverse order. Very probably the sample will show some color. Perhaps the yellow or orange of the first series won't come out even with no load on the sample. This indicates that the sample is stressed. If the part has not been overstressed the color will disappear. The retention of color is dependent on a number of factors, such as quality and kind of material used, stress values, etc.

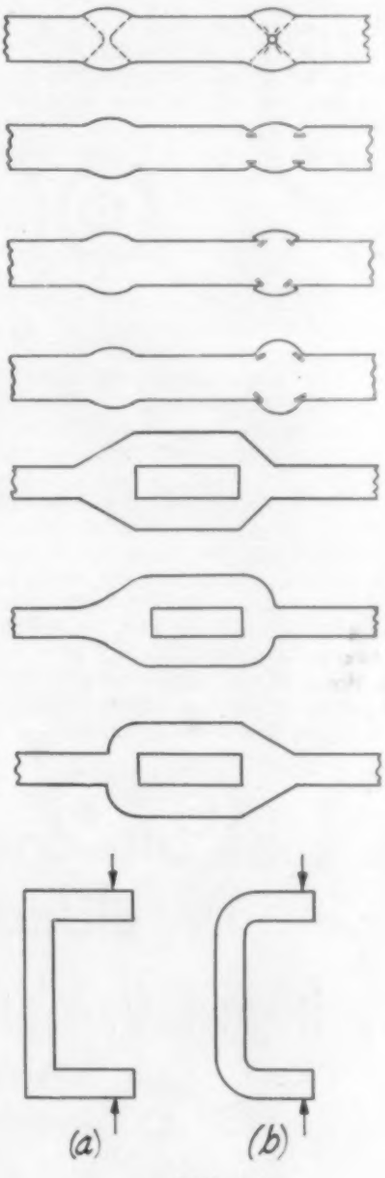


Fig. 3

Upon the basis as given, above models of designs may be studied and the stress distribution analyzed. There are a few simple statements which will be helpful in laying out the preliminary design.

There must be no abrupt interruption of the surfaces of the stress-carrying members. The smoother the surface the lower the ratio of maximum to average stress.

The section may be viewed as a flume, carrying water. Wherever turbulence occurs, will be stress concentration.

The effect of the shape of joints is very clearly shown. For example in a 30–60° fillet weld, the distribution of stress is much better than in 45° (See JOURNAL OF THE AMERICAN WELDING SOCIETY, October 1932, Distribution of Stresses in Butt Strap Joints, by S. C. Hollister and A. S. Gelman).

As illustrative of the method of using the polariscope, the following illustrations are given:

The top illustration of Fig. 3 shows a double Vee correctly made, and alongside it is a double Vee in which the fusion is not complete at the center. Both of these being in the same model and subjected to the same load conditions, comparative results may be easily observed. As the load is increased, it can be seen where the stress concentrations occur and what their relative amounts are, and a quick, direct comparison can be made. The other figures show an undercut, and overlap, and bead which is too high compared with standard beads of normal and satisfactory cross sections. On the double butt strap joint a 30–60 is compared to a 45° bead, and a 30–60 is compared to a very rounded bead, both of these being loaded under very similar conditions the comparative actions may be readily studied.

A "U" or "C" clamp is shown, with square corners and also with rounded corners. Obviously the rounded corner will give materially better strength distribution, but observation and study of the shape will reveal some very startling results.

Metal deposited by shield-arc process has fatigue value of 28–32,000 lb. per sq. in. It is necessary, therefore, in welding design that the shape of the part be most carefully considered. Smooth, easy changes of contour, resulting in low ratio of maximum to average stress, mean long service life and low cost due to the proper use and distribution of the metal.

Welding permits the best distribution of metal. Modern electrodes of shield-arc type deposit high quality metal, so that the design really becomes a question of shape of the part and a study of the stress distribution caused by their shape. Such a study, properly carried out, will result in a welded design and product which will meet the severe economic conditions outlined at the beginning of this article.

Discussion, by THOS. H. EVANS†

THE writer believes that Mr. Smith has well brought out by the illustrations in his article the necessity of a thorough knowledge of fatigue stresses on the part of engineers. It certainly seems true that economy of material and prevention of failures in brittle media necessitates a thorough analysis, either mathematically or by models, of maximum stresses. The simple apparatus that is described is useful for doing a certain amount of this experimental analysis.

The author's brief outline of the optical fundamentals of photoelasticity seems predicated on the assumption that most engineers have a rather good grasp of optics. The writer has found the opposite to be true in most cases and believes the optical fundamentals must be taken up in somewhat more detail.

The box apparatus proposed by the author has certain limitations which it might be well to point out. While it serves to give a complete image of the maximum shearing stress contours, any further analysis requires either a rotation of the model or the box in order to determine stress directions. The lesser of the two evils would be to rotate the model and this would require some precise apparatus if the analysis is at all accurate. If an experimenter was only interested in locations of stress concentrations or magnitudes of boundary stresses, then the apparatus proposed is excellent. When, however, it is necessary to know interior stress values or the principal stress directions for the whole model, it seems justifiable to adopt a more elaborate set-up, using Nicol, or equivalent prisms, each of which can be rotated about its optical axis.

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Discussion on "Investigation of Welded Seat Angle Connections"* by Inge Lyse and Norman G. Schreiner

By CYRIL D. JENSEN†

MY DISCUSSION of the progress report of the seat angle study pertains to possible formulas which may be used to predict the ultimate capacity of a welded seat angle. The figure presented herewith shows the results of the tests made at Lehigh University and also shows several attempts to supply a formula for predicting the ultimate capacity.

As will be noted, I have joined by lines those specimens which are related. Reading from left to right, the first series, A 443–1, –2 and –3 shows the effect of increasing the moment arm. The effect of increasing the moment arm is also shown in specimens A 444–1, –2 and –3, and again in specimens A 884–1, –2 and –3. Specimens A 443–1, A 444–1 and A 444a are related, the first and second showing effect of increasing weld size, and the second and third showing effect of omitting the lower half of the welds. Effect of increasing the size of weld is also shown in specimens A 463–1, A 464–1 and A 466–1 and again in specimens A 643–1 and A 644–1, A 654–1 and A 655–1, A 843–1 and A 844–1, and lastly in specimens A 884–1 and A 886–1. Effect of thickness of angle is indicated by specimens A 644–1, A 654–1 and A 664–1, also by specimens A 844–1, A 864–1 and A 884–1.

The test results are shown by lines *A*, *B* and *C*. Line *A* connects load points where first visible crack appeared in the whitewash covering the welds; line *B* indicates points where the cracks definitely opened up;

* Presented at Fall Meeting, A. W. S., published in this issue of JOURNAL.
† Asst. Prof., Fritz Engineering Lab., Lehigh University.

and line *C* shows the ultimate loads placed on the seat angles.

The lines representing the predictions as determined by various possible formulas are indicated by the letters *D*, *E*, *F* and *G*. Lines *F* and *G* are most easily disposed of and will, therefore, be discussed first. Line *F* represents predictions based on shear only. The estimated ultimate load equals the length of weld on the seat angle multiplied by the ultimate unit stress in shear, namely, 12,000 lb. per lin. in. for a $^3/_8$-in. weld and ultimate stresses for other weld sizes in proportion. It is very evident that the predictions are absurdly high and that the line cannot be corrected by some constant since it is not at all parallel to the lines showing test results. This method does not take into account the effect of bending, which leads to the next discussion.

Line *G* represents predictions based on bending only where the two welds are assumed to resist the bending moment by pivoting about the mid-height of the vertical leg of the angle. It is observed that the results are much too high (in the 8-in. angle group the predictions could not be plotted on the graph). It might also be noted that for the 6-in. and 8-in. angles the section modulus is so great that the predictions by this method even exceed those of the preceding method. One exception is noted in the thick but short-legged angles A 463, A 464 and A 466 (4-in. vertical leg, thickness of $^5/_8$ths of an inch, and weld sizes respectively $^3/_8$, $^4/_8$ and $^6/_8$ in.). Due to the unusual thickness of angle the vertical leg was stiff enough to resist the bending stresses according to the formula. Specimens A 655 and A 664 show an important flaw in the formula under discussion. As may be noted, thickness of angle is ignored in the formula. As a result the two angles are considered as of the same size but with the second named angle having a smaller weld by $^1/_8$ in. Therefore, according to prediction this angle should be weaker by 20 per cent, whereas, it is actually stronger than the other angle. If, on the other hand, the effective depth of the welded connection to resist bending be based on the thickness of vertical leg of angle multiplied by some constant, then the gain in strength of the second angle over the first is 44 per cent or a net gain of 24 per cent, whereas 27 per cent is actually the case if based on the loads where first crack appeared. Thus, it is observed that this method of predicting the ultimate strengths, based on neglecting shear and considering bending only, where the effective depth for computing section modulus is the length of the vertical leg, has some merit but contains some real flaws.

The two remaining methods, represented by lines *D* and *E*, give rather favorable results and evidently should be seriously studied. The first method (*D*) depends on shear plus bending, where the effective depth for calculating the section modulus is six times the thickness of the angle. In other words, the shearing stress equals the total load divided by the total length of welds; the bending stress equals the bending moment divided by the section modulus, or:

$$f_s = \frac{W}{2L}$$

and

$$f_t = \frac{We}{bd^2/6} = \frac{We}{b\,6t^2} = \frac{We}{12t^2}$$

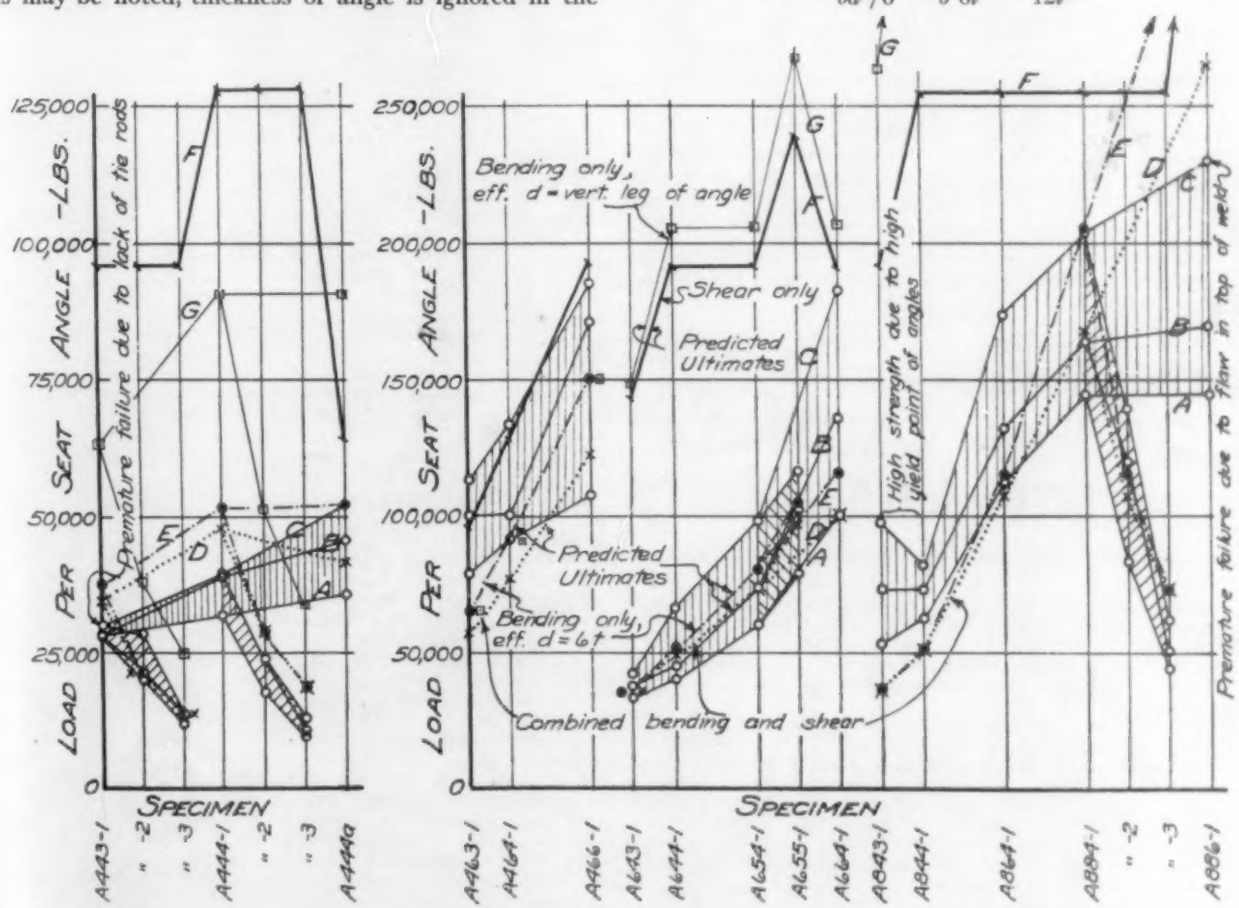

FIG 1. ACTUAL AND PREDICTED RESULTS SEAT ANGLE INVESTIGATION.

where f_s and f_t = stresses in pounds per linear inch of weld in shear and tension, resp.
We = bending moment in lb.-in.
L = length of one weld in inches
b = number of fillets taking the bending (in this case, 2)
d = effective depth in bending in inches
t = thickness of angle in inches

Now the resultant force in pounds per linear inch of weld is,

$$R = \sqrt{f_s^2 + f_t^2}$$

It will be observed that the direction of the resultant is not far from that found in the qualification tests (end-welded specimens) and, therefore, the results of these tests were used (R in the above formula) in making the predictions. Substituting values for f_s and f_t as given above, and solving for the predicted load W there results,

$$W = \frac{2R}{\sqrt{\frac{1}{L^2} + \left(\frac{e}{6t^2}\right)^2}}$$

The second method under consideration (E) neglects the effect of shear but is otherwise the same as the first method (D). The resulting formula is,

$$W = \frac{2R}{e/6t^2} \text{ or } \frac{12Rt^2}{e}$$

There is little choice between the two formulas just given. The results are good except for specimens A 443–1, A 444–1, –2, and –3, and A 886–1. Specimen A 443–1 failed prematurely due to the absence of the tie rods found in the later tests. Specimens A 444–1, –2 and –3 do not show a proportionate increase in load-carrying capacity over the preceding series (weld size increased from $^3/_8$ to $^1/_2$ in.). No explanation is afforded but it is felt that somehow the specimens were deficient. Specimen A 886–1 failed prematurely due to a flaw at the top of one weld. The writer favors the method (D) of combining shear and bending stresses, basing the effective depth in bending on a constant times the thickness of angle.

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WELDING SOCIETY ACTIVITIES AND RELATED EVENTS

Corrosion Resisting Steels

(From Information Supplied by E. E. Thum)

Inaccurate rumors of serious failures of corrosion resisting steel in warships of the U. S. Navy have been circulating for several months, and finally reached publication on the first page of the *New York Times* and an Associated Press dispatch saying the Navy had decided to eliminate such steel from vessels now under construction.

The Bureau of Construction and Repair, U. S. Navy, has been interested in corrosion resisting steels ever since their commercial production. They offered opportunities for weight saving and permanance when replacing galvanized steel or wrought iron; the latter either had to be used in extra heavy section to provide for corrosion losses or replaced before the ship became obsolete. Weight saved on the top sides increases the stability of the ship and permits an equal increase in power plant or armament.

Satisfactory results encouraged the naval constructors to put corrosion resisting steel into two applications in which unfortunately it did not stand up—namely, gasoline stowage tanks and fire lines. Let us examine the circumstances surrounding such failures.

Salt water is pumped into the bottom of the tanks so the gasoline can be drawn off under hydraulic pressure at all times; consequently the stowage tanks contain variable quantities of gasoline, doped with tetra-ethyl lead and ethylene dibromide, and sea water more or less fouled with marine organisms or diluted sewage. Tanks on the first aircraft carriers had been made of galvanized steel plate, welded, with welds tinned—a reasonably satisfactory construction. On the newer ships the tanks were to be built into the hull in quite inaccessible locations, and the use of 18–8 promised absolute immunity from leakage (most dangerous in confined spaces aboard ship!) for the entire life of the hull.

The second unsatisfactory experience was with fire lines of thin-walled seamless tubing, installed on the latest 10,000-ton cruisers. In older ships galvanized steel or iron pipe has been used, much heavier in wall thickness and of less life than the hull. It was anticipated that the 18–8 would resist sea water perfectly, and not only save considerable weight, but also the cost of expensive replacements.

In both situations the stainless steel failed by pitting in as short a time as six months! These two are the applications which have given all the trouble, which are being removed from existing ships, and which will not be resumed until the cause is definitely known and cured. It would be a dis-service to corrosion resisting steel to gloss over the facts, and allow other users to stumble into similar troubles. A multitude of laboratory salt spray tests and extensive naval experience prove that commercial 18–8 is totally resistant to common salt (sodium chloride), sea salt and sea water when moving vigorously and aerated, or to seashore and marine atmospheres. Trouble by pitting apparently exists only in stagnant sea or harbor water, and there is not the least cause for worry about a multitude of applications in dozens of industries where chloride ions, stagnant solutions and foul deposits are not encountered or not permitted.

Amendments and Addition to By-Laws Adopted November 5, 1934

Article IV—Sec. 8.—The ballot sheet shall list the names of the candidates proposed by the Nominating Committee and the respective offices for which they are candidates and the names of the candidates nominated by letter ballot as provided in Section 6. Candidates selected by the Nominating Committee shall be identified by an asterisk. Candidates of the Nominating Committee may be voted for in a group.

Article VII—Sec. 1.—With the approval of the Board of Directors the President shall appoint:

(*e*) A Nominating Committee of seven members. Announcement of the appointments shall be made by the President, at the Fall Meeting (Business Session) of the Society. This Committee shall consist of a chairman who shall be a Past-President of the Society and six members (not members of the Board of Directors), one of whom shall be a Past-President of the Society. The Committee shall deliver to the Secretary in writing on or before the last Tuesday in January (of the following year), the names of its nominees for the various elective offices next falling vacant together with the written acceptance of each nominee.

Article VII—Sect. 2.—(add.) An Advisory Committee to serve in an advisory capacity when called upon by the Board of Directors. This Committee is automatically perpetuating and is comprised of all Past-Presidents who are not members of the Board of Directors. The Junior Past-President shall be chairman. In the absence of the Chairman the second, third, etc., Junior member of the Committee shall act as Chairman.

Committees Scheduled to Meet during 1935 A. S. T. M. Committee Week

The committees of the American Society for Testing Materials listed below will hold meetings in the Warwick hotel, Philadelphia, during A. S. T. M. Committee Week, March 4–8th. A number of others are considering meeting and no doubt many will decide to participate. The research and standardization work sponsored by the respective committees will be reviewed and plans made to present the results to the Society:

A-1 on Steel
A-2 on Wrought Iron
A-5 on Corrosion of Iron and Steel
A-6 on Magnetic Properties
Subcommittees of B-2 on Non-Ferrous Metals and Alloys
B-3 on Corrosion of Non-Ferrous Metals and Alloys
B-5 on Copper and Copper Alloys
B-6 on Die-Cast Metals and Alloys
C-3 on Brick
C-10 on Hollow Masonry Building Units
Subcommittees of D-1 on Preservative Coatings for Structural Materials
D-2 on Petroleum Products and Lubricants
D-4 on Road and Paving Materials
D-5 on Coal and Coke
D-8 on Bituminous Waterproofing and Roofing Materials
D-11 on Rubber Products
Subcommittees of E-1 on Methods of Testing
Subcommittees of E-4 on Metallography
Coordinating Committee on Non-Ferrous Metals and Alloys

Fourth Annual Welding Conference

The Fourth Annual Welding Conference, conducted by the Department of Industrial Engineering, Ohio State University, will be held February 28th and March 1st in the Industrial Engineering Building. An interesting program, consisting of papers, demonstrations and exhibits, has been prepared.

Lafayette Engineering Conference

The Second Annual Engineering Conference will be held on the campus of Lafayette College, Easton, Pennsylvania, for two weeks—June 23 to July 6, 1935.

Planned for young men who will have completed at least their Junior Year in Preparatory or High School. Program to be similar to the successful one of last year.

Experiments and Exercises in College Laboratories
Talks on Fields of Engineering by National Authorities
Visits to Typical Modern Industrial Plants
Individual Aptitude Determinations
Personal Vocational Interviews and Advice by Experts
Recreation

For further information and complete details, address, The Director of the Engineering Conference.

William Zorn

The C. H. Dockson Company of Detroit, Michigan, announces that Mr. William Zorn, formerly Welding Engineer for the Detroit Edison Company, will join their organization in the capacity of Consultant Welding Engineer February 1st.

Mr. Zorn's services, as a consulting engineer or as a speaker, will be available to any one with arc welding problems in the middle west.

His experience embraces every phase of metallic arc welding including atomic-hydrogen welding, tank and structural welding, high- and low-pressure piping, alloys, hard facing, etc., as well as gas welding and cutting.

Specification Documents for Building Materials and Construction

Classified and arranged by David H. Merrill, structural engineer, and Theodore C. Combs, civil engineer, and published under the approval and direction of the Pacific Coast Building Officials Conference.

556 pages, 6 x 9, with complete illustrations, tables and diagrams as found in the original documents. Price $5.00.

Twenty-Fourth Annual Safety Congress

The Twenty-Fourth Annual Safety Congress of the National Safety Council, Inc., will be held in Louisville, Kentucky, on October 14–18, 1935.

EMPLOYMENT SERVICE BULLETIN

POSITION VACANT

V-57. Wanted. Men trained in electrical machine work, armature or stator winding.

SERVICES AVAILABLE

A-207. Wanted—position as representative. Will act as sales representative in the Pittsburgh district. Can furnish references.

SECTION ACTIVITIES

BOSTON

The February meeting will be held on Friday evening the 15th at 7:30 P.M., at the Engineers Club. Dinner will be served at 6:30. This is to be a joint meeting with the Boston Section, American Society of Mechanical Engineers, and the section will have the pleasure and privilege of having as guest speaker Dr. D. S. Jacobus, President of the AMERICAN WELDING SOCIETY. Dr. Jacobus will speak on "The Development of Rules for Fusion Welding Pressure Vessels."

CHICAGO

The January meeting of this Section was held on the 25th. Mr. Thornton F. Bright, Consulting Engineer, presented a paper on "Plate Welding" and Mr. Jules Muller, President of Hollup Corporation, presented a paper on "Alternating Current Welding."

Dr. D. S. Jacobus, President of the AMERICAN WELDING SOCIETY, and Prof. John F. Keller of Purdue University, will be the speakers at the meeting at 8:00 P.M. on Friday, February 22nd. This meeting will be held in the Auditorium, 2nd Floor, Engineering Building, 205 West Wacker Drive, and will be held jointly with the A. S. M. E.

DETROIT

On January 18th at the Book Cadillac Hotel, Detroit, Mr. P. W. Fassler addressed a meeting of the Society of Automotive Engineers on Resistance Welding. His address was illustrated by well-selected slides showing both design methods and practical application.

The February meeting was a joint meeting with the American Society for Metals held on the 11th. Dr. Henry A. Luce of the Wayne County Medical Association spoke on "Social Medicine in Relation to Industry." The speaker of the evening was Mr. Robert E. Kincaid, Consulting Engineer, who delivered an address on "Welding Technique and Testing."

NEW YORK

The February meeting of the New York Section will be a joint meeting with the Power Division of the American Society of Mechanical Engineers on the 14th. Prof. S. C. Hollister, of Cornell University, spoke on "Design and Construction of Welded Penstocks for Boulder Dam." There was an exposition of the design and construction of the huge pipes now being installed for the power development at the world's largest dam.

PITTSBURGH

Dr. D. S. Jacobus, President of the Society and Advisory Engineer of the Babcock & Wilcox Company, presented his address, "The Historical Development in Welding with Particular Reference to Its Application to Pressure Vessels," before a joint meeting of the Mechanical Section of the Engineering Society of Western Penna. and the Pittsburgh Section, Thursday, January 24th, in the Wm. Penn Hotel.

Dr. Jacobus in his talk and with the use of slides traced the development of the welded pressure vessel from the uncertainties of the early days to the finished product of the present time, bringing out the part played by the Boiler Code Committee in the process. Dr. Jacobus also touched on the Boulder Dam job and showed some slides as well.

Arrangements have been completed for a regular meeting to be held Wednesday night, Feb. 20th, in the Fort Pitt Hotel, at which time R. F. Helmkamp of the Applied Engineering Department of the Air Reduction Sales Company, New York, will present a paper on "Advances in Machine Construction by Gas Welding and Cutting."

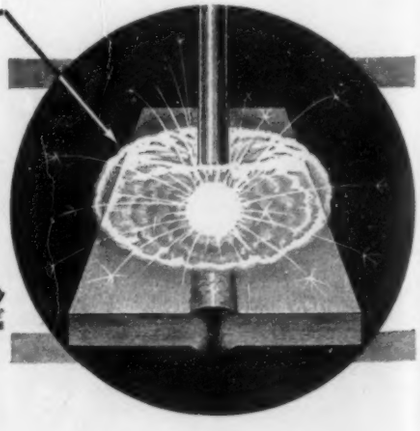
SAN FRANCISCO

The January meeting was held on the 18th. Mr. J. Frederic Wiese, Assistant to the Vice-President of Lukens Steel Company, presented an address on "Cromansil, A New Quality Steel—Its Application and Fabrication in Welding, Design and Construction."

Mr. C. B. Leahy of Air Reduction Sales Company gave a few minutes' discussion of the most interesting subjects which have appeared in the last issue of the JOURNAL.

THIS ENVELOPING CLOUD
assures a GOOD WELD! . . .

The requirements for good welding are no different than those required in any other step of your production. - - - Quality of materials, speed of application and character of finished work are the important factors. - - - Page Hi-Tensile Electrodes are better electrodes. - - - They are pure metal and are heavily coated. - - - This coating provides a small protecting cloud which closely surrounds and shields the arc—spatter loss is less. A larger amount of actual usable weld metal per inch is deposited, the formation of oxide and nitride impurities is prevented, the weld is completely covered, thereby lowering the cooling rate which in turn increases the ductility of the weld metal. - - - Look to Page for better welding and to the Page Engineering Staff for counsel if your welding problem seems to you to be particularly difficult.



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